Modern Weapons of War

By Land, Sea, and Air

BY

CYRIL HALL

Author of "Treasures of the Earth"
"Conquests of Engineering"
"Wonders of Transport"

Illustrated by Actual War Pictures

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Contents

Illustrations

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CHAPTER I

Modern Guns and Gunnery

THOSE of us who are not actively connected with the army or the navy in the great war now raging—the great bulk of the community, that is—have very dim and hazy notions of the weapons with which modern battles on land and sea are fought.

We recognize that they are very wonderful and terrific, a thought that has been common to mankind for six centuries at least. And every one of us probably has, deep down in his heart, a feeling of loathing for the implements with which ships are sunk and cities razed,

and endless carnage caused deliberately and in exultation; and a sigh for the kink in human nature that makes the whole ghastly business possible. To brain your enemy with a club, or run him through with clean, cold steel, was warfare with an honest ring; to scatter bursting shell upon him from a hidden gun or sink his ships with devilish devices under water is surely far less glorious.

For the last twenty years the best brains of the world — the greatest mathematicians, the greatest chemists, no less than the greatest masters of applied science—have been engaged in a world-struggle in which each Great Power has sought to outdo the others in what we may be allowed to call destructive efficiency, and to a lesser extent in obstructive efficiency as well. To be so well armed that your adversary will not dare to attack you is obviously the surest way to remain at peace with him. But this axiom can hold good only so long as your own superiority is unapproachable, or so long as your adversary thinks it is. Pedagogues and politicians have been telling us for years that a great display of arms and armour would ensure peace. Unfortunately, pedagogues and politicians sometimes take

narrow views of great problems, in common with the rest of us; and we, as a nation, are too apt to regard our own progress in the science of armament as ahead of that of other nations. As a matter of fact, the world's brains are pretty equally divided. If we build the largest and most formidable battleships in the world, we may be sure that our opponent is meanwhile perfecting instruments by which they may be destroyed.

It is worth while to remind you that the modern fighting-machine, in so far as it is mechanical, is purely a product of little more than twenty years' growth—much less than that, in fact, in its details and refinements. Says Sir Alfred Noble, in the Preface to his *Artillery and Explosives* (John Murray, 1906):—

"When I entered the Service, the line-of-battle ships were all sailing vessels, and their arms and appliances differed but little, except as regards size, from those in use in the days of Henry VIII and of Queen Elizabeth. Mechanical contrivances the older officers would not hear of, and I have heard more than one declare that no contrivance should be allowed on board a man-of-war which could not be

handled and repaired by the bluejackets, who had proved the efficiency both of men and material in so many victorious actions.

"The same spirit influenced the older Peninsular and Waterloo officers of my own corps, the Royal Artillery, and I remember an occasion on which it was curiously shown. After the introduction of rifled artillery a dinner was given by the Royal Artillery Mess at Woolwich to the late Lord Armstrong. It was the duty of the President to propose the health of the guest of the evening, which was gracefully done; but after describing what had been effected by Sir W. Armstrong, the orator concluded: 'But for myself, I am radically opposed to any change'.

"To illustrate the distrust with which novelties were regarded, I may mention that I was secretary to a committee which had its meetings at the War Office, called, I think, the Committee on Plates and Guns, and at their meetings were discussed, among other things, the details of the gun intended to be the heavy gun for both land and sea service. The artillery officers pressed for a gun weighing 7 tons, but the naval officers were doubtful whether so heavy a gun could be carried on board ship.

The disputed point was compromised by making the gun $6\frac{1}{2}$ tons, but as strong doubts were expressed as to whether rifling would be successful in such a gun, the calibre was finally ordered to be such that it would fire 100-pound spherical shell if the gun were unsuccessful as a rifled gun. . . . The objections to anything like a mechanical contrivance were, as I have mentioned, very strong, especially among some of the older officers, who could hardly be got to look with patience upon any appliance to which they were not accustomed."

This, of course, is ancient history, and is only a later parallel of the attitude of my Lords at Whitehall in regard to many other mechanical contrivances which were urged on their attention in the early nineteenth century; as, for example, the use of steam for ship propulsion, iron-ship construction, and the adoption of the screw propeller. However, such mistakes as these have long since been expiated, and the fighting machinery of to-day is as perfect as human ingenuity can make it. How perfect that is I hope to show in this book.

At the time of which Sir Alfred Noble speaks the inability of the authorities to understand the import of the "innovations" that were brought

to their notice had very serious consequences for the British nation. Other States were quick to profit by our inaction, with the result that we were badly behind them in the matter of gun equipment both on land and at sea.

The modern gun is truly an amazing machine; in a sense, perhaps, it is not too much to say that it is the most perfect piece of mechanism in existence. It has developed, not steadily, as have most other forms of machinery—as has the locomotive, or the marine engine, or the electrical machine, for instance—but with leaps and bounds, so that it is rather difficult for the untechnical person to follow its evolution through its later stages, even, say, from the 110½-ton monstrosity of the 1885 *Benbow* and *Collingwood* to the smaller but infinitely more powerful 13.5 weapons of to-day. Of course the development of the gun has been parallel with the progress made in many different sciences. The metallurgist has given us alloys without which the guns of to-day would not be possible, and the enormously hard steel for armour-piercing projectiles; while the steel-maker, the foundry-man, and the heads of the great armament firms have perfected the elaborate and costly machinery by means of which

the guns are actually made. Simultaneously the chemist has been striving to improve the explosives which form the motive power of the huge projectiles and the bursting charges which add enormously to their terrible power. Apart from the researches of scientists, mathematicians, chemists, metallurgists, and steel-founders, experts in a hundred branches of mechanical engineering are constantly planning improvements in the details of big-gun mountings. There is hydraulic machinery for moving and loading the guns, marvellous pieces of machine-work for enabling the laying and firing to be done in as short a time as possible, electrical apparatus of a dozen forms, apparatus for sighting, and so on and so forth, almost without end. The result is, as I have said, as perfect an instrument of destruction as human knowledge and ingenuity is able to evolve; which is not to suggest that it will never be evolved any further.

Every step forward in the actual mechanical efficiency of guns and torpedoes—greater range, increased rate of fire, and, on land, increased mobility also—has a threefold effect to which most people are blind. It influences the tactical difficulties of commanders of forces on sea

and on land, sometimes quite upsetting preconceived notions of naval or military strategy. That, of course, is only to be expected; it affects all countries equally, and all are alive to its importance; but it is not a matter with which we can deal here. The second effect is on the taxpayers' pockets, and touches a nation's wealth; again, this effect is hardly germane to our subject. The third is far more important. It deals with the *moral* effect of innovations and improvements in the artillery of war. Thus, the most useful weapon is not necessarily the most deadly. Your gunners may be so well trained that they can "make good" with every shot, and still leave the enemy undaunted and ready to die to the last man; while a hail of shrapnel coming from an unseen battery may unnerve a great body of men, seriously impairing their fighting qualities.

This matter of the moral effect of engines of war is as old as war itself. The Britons fled panic-stricken from a single elephant when Cæsar forced the Thames against Cassivelaunus, and Crécy was won as much by the noise of the English cannon as by anything else. To-day it is just as important a factor in warfare as in the days when men were less sophisticated

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Photo Cribb, Southsea

A BROADSIDE FROM A SUPER-DREADNOUGHT

H M S. *Monarch* firing 12,500 pounds of steel and lyddite, which represents power sufficient to lift the ship a foot into the air.

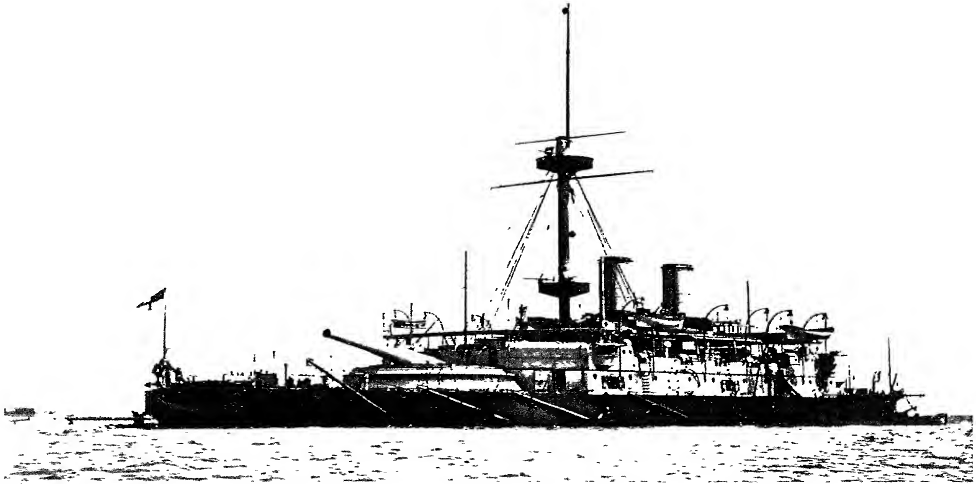


Photo West & Son, Southsea

BIG GUNS WHICH HAVE BEEN ABANDONED

The 110-ton guns on the old H.M.S. *Benbow*. Twenty-six years ago was inaugurated the "big-gun era". But these monster guns were slow of fire, and their life was estimated at little more than 70 rounds

and more easily frightened. An air-ship or an aeroplane dropping bombs over a besieged town has a very real terror for the defenders, though the harm it can do may be almost negligible, and not to be compared with the destruction from the guns of the siege-train. However strange it may seem, the relatively harmless air-craft has a highly demoralizing effect.

At sea this problem of moral effect is a little different, since the menace hidden in torpedo or mine is a potential disaster. If a mine explodes beneath a ship, be she big or little, there is, as a rule, little chance that she will remain afloat, at all events as a fighting unit. To have to move much in mined waters, or to be continually exposed to raids by submarines, imposes a strain on officers and men that can be easily understood. It is generally believed to be part of Germany's war policy so to wear down our numerical superiority at sea by mines and torpedoes that her high-sea fleet will at last be in a position to meet our own fleets in actual battle with a reasonable chance of success. She also counts largely on the demoralizing effect of this "wearing down" process on our men.

Recent progress in field ordnance is no less

obvious than in the armament of fighting-ships. Although, as a rule, we hear less about field-guns than about the more formidable—and more expensive—naval guns, yet the increase in the efficiency of the soldier's weapon is as great as in the sailor's. The effective range, rapidity of fire, and destructiveness of the projectile have all increased enormously since the last great campaign was fought in Europe; and equally important is the greater mobility of the guns. It is not very long ago since it was necessary to add weight to a gun in order to make it more formidable: the heavier the projectile the heavier the gun. To-day field-guns are lighter than they were, and infinitely more powerful. Thus, the 18-pounder of the field artillery is a good deal lighter than the old 15-pounder it superseded. To an army in the field the mobility of its guns is of vital importance. A gun that can bowl easily along a good hard road becomes useless as soon as it sinks into the ground when off the road. Again, the fewer horses necessary to a gun team the better; for which reason motor-hauled guns are now largely used. The huge German 11-inch howitzer (described in Chap. V) is a good example of the value of the petrol

engine to field artillery. Without its motor-driven carrier the gun would be impossible; owing to its huge weight horses would be out of the question.

In many other directions, too, one can see how the great nations have added to their fighting efficiency by making use of a great many devices and inventions not primarily intended for warlike use. Wireless telegraphy and the telephone have been pressed into the service since the last great European campaign. The internal-combustion engine adds enormously to an army's transport facilities, and, apart from motor-cars and wagons of a hundred kinds, it drives the submarine and the air-ship and the aeroplane. The aeroplane itself is quite a new factor in warfare, though balloons played some part in the siege of Paris in 1870, being used for observation and in one or two cases for communicating with the world outside the besieged city. Aeroplanes were used in Italy's operations in Tripoli in 1911, but the idea of protecting warships with armour to defy attack from the air is only now finding expression.

When the great Battle Fleet assembled at Spithead in July, 1914—at a time when, though few of us realized it, the war clouds were already

gathering, and the chancellories of seven or eight capitals were filled with doubts and fears —this great fleet, more formidable than any ever seen before, was visited by thousands upon thousands of gaping sightseers, come from many a far inland town, not of Britain only, but of the heart of central Europe. The thing about this armada that most impressed the crowds was not the numbers of its ships, nor their size, nor their ugly unshiplike shapes and outlines. The guns had the highest fascination for them. It was so wonderful that out of the simple-looking tubes that bristled on the Super-Dreadnoughts could issue missiles that would travel accurately for twelve miles or more, or at half that distance send to the bottom the mightiest ship afloat. And there was far less thought for the hidden wonders of science that had made the guns, and made possible their manipulation and their deadly effect, than for the guns as ugly grey tubes and nothing more. To too many of us, I think, a gun is merely a gun—as electricity is light and power—a commonplace mystery that it is hopeless for commonplace folk to try to probe.

The object of this book is to help untechnical readers better to understand the artillery with

which nations now wage war; and to show, too, how the brains of the world's most eminent scientists have improved and again improved the weapons with which our fathers fought, besides bringing into being a multitude of destructive appliances of which they had never dreamed. There is an ingenuity about our modern engines of war that, however diabolical we may regard them, cannot fail to hold our profoundest respect and admiration. The warrior perhaps has lost something of his ancient glamour, and has become less human and more automatic than the men who fought the battles of many unconscionably long centuries of the history-books. If that is so, at least we can console ourselves with this: that there is romance enough in his weapons to-day to imbue them with an interest they never had in days agone. To a suggestion that sights would be useful additions to his guns, Lord Nelson retorted contemptuously that he hoped "our ships would be able, as usual, to get so close to our enemies that our shot cannot miss the object".

The main armament of the *Victory* comprised 42-pounder and 32-pounder carronades. "Smashers" they were called in the Service,

so great was the execution they did. These "smashers" were effective at a range of some five or six hundred yards, the distance at which naval engagements were then fought. A comparison of the guns of the *Victory*, the *Victoria*, and the *King George V* shows very clearly the marvellous growth made in the power of naval guns. The heaviest gun on the *Victory* weighed 3 tons, and threw a 68-pound shot; while the total amount of metal she could discharge from a broadside was 1158 pounds, less than the weight of a single shell from the 12-inch guns of the Dreadnought. The *Victoria*, the battleship that was rammed and sunk by the *Camperdown* during evolutions off the Tripoli coast in 1893, was armed with the prodigious 110½-ton guns that created such a sensation in the later 'eighties. These monsters fired an 1800-pound shell, a figure that has hardly been surpassed. The *Victoria's* total broadside was 4750 pounds. The 13½-inch guns of the *King George V* are lighter than the *Victoria's*, and throw a projectile weighing 400 pounds less; but the full force of her ten guns when trained as a broadside is infinitely greater, and attains the huge total of 14,000 pounds, while the destructive power of each shell is very much more potent

than the monstrous projectile discharged from the old 110½-ton guns. How great the change has been, and how terribly efficient are the great guns of to-day, we shall see in later chapters.

CHAPTER II

Guns in the Making

A PAIR of $13\frac{1}{2}$-inch guns and their mountings cost the nice round sum of £110,000. They occupy about ten months in the making; from which it may be inferred that a gun is not such a simple thing as it looks. As a matter of fact, the modern gun is a superb masterpiece of man's handiwork. The men who fight the guns—they who, by fingering a few levers and switches, send hurtling from a modern British battleship some $5\frac{1}{2}$ tons of steel and lyddite on a journey at the rate of *2040 miles an hour*—have probably very hazy ideas of how the monstrous engines were made. And the steel-founder who fashioned them could no more fire them than you or I could. Both gunner and gun-maker help in the same mission, but the gun-maker's share is by far the more important. In this chapter we shall see how the guns are called into being. Their beginning is a very humble one—a heap of blackish iron ore—and they are cradled by humble men.

We will imagine the iron ore to be smelted in Sweden, where the most valuable kinds are chiefly found, and to arrive in a great Sheffield steelworks as iron pigs. Here it is made into steel by the Siemens-Martin process. In this process, which is perhaps less impressive to watch than the commoner Bessemer method, the pig-iron is melted in huge crucibles. It is a furious business, in which the workers have to call to their aid the fiercest fires that can be made. When the bath of molten iron is hot enough, shearings of steel rails and other steel scraps of known quality are added. Samples are taken from time to time during the melting, just as though it were some Plutonic hotch-potch, and when the right point is reached, when the steel "boils", as the foundry-man calls it, and all the impurities have combined with the oxygen of the air and passed out, as gas, with much angry protest, a very carefully calculated amount of carbon is added to take the place of the carbon that has been burnt out. Probably, too, as a sort of final seasoning, some other metal, such as nickel, will be added. The nickel will add tremendously to the toughness of the steel.

You must understand that the whole of

this steel-making process has to be watched and tended from beginning to end with the most scrupulous care. Steel, of sorts, is so common that there is no finding its beginning or its end; but steel of high quality is an intensely complicated product—a product of which the best brains of the greatest metallurgists of modern times are a component: a product that alone makes the big gun possible. The material is everything. When the gun is fired the pressure in the combustion-chamber is stupendous. The explosion of the cordite cartridge imparts a "muzzle energy" of very nearly 70,000 foot-tons—equal to the combined blow of 140 steam-hammers of the most formidable size.

Our steel having been made, we run it out of the crucible into an enormous ladle, taking care, though, to leave enough behind to continue the melting of the steel scraps. Steel has such an intensely high melting-point that it is only possible to dissolve it by adding it, bit by bit, to molten metal at a terrific temperature. The ladle into which the steel is run holds several tons. It is lined with firebrick, and runs on rails. The steel from the furnace rushes into it in a dazzling, shrivelling cascade,

an awful sight. When it is full the ladle moves slowly along the foundry until it stands over the ingot pit, in which is a mould to receive it. If the steel is to make the barrel of one of the biggest guns, the ingot mould will be about 13 feet high by 2 feet internal diameter, and will hold some 50 tons of metal. To this huge amount several furnaces will each contribute their share of liquid steel.

While the ingot is cooling, let us take a glance at the great changes that have taken place in gun-making in recent years. In the last chapter I mentioned the 32-pounder carronades that were mounted on the *Victory*. These guns were famous in their day, and were called after the Carron foundry, in Stirlingshire, where they were first made in 1779. They were made of cast iron, at that time and for many years afterwards the strongest metal known. Now cast iron is very apt to contain flaws, and the flaws in the cast guns could only be discovered by the gunners. If the gun did not burst, well and good; if it did burst, its crew had no chance to condemn the unseen flaws. Yet such guns as these, throwing solid shot ranging from 6 to 68 pounds, remained in use till about 1855. They had smooth bores, and there was

great loss of energy owing to what is called "windage"; that is to say, a portion of the gases caused by the explosion of the gunpowder escaped past the ball, as the latter could not be made to fit tightly enough. However, in 1853, there appeared on the scene a man whose efforts to improve the guns completely altered the whole aspect of warfare, both on sea and land. This was Mr. William Armstrong, afterwards Lord Armstrong, the founder of the world-famous Elswick ordnance works. First of all he set to work to improve the material.

When a gun is fired it is subjected to enormous stresses. The explosion tries to split the gun open longitudinally (circumferential tension), and also to pull it apart lengthwise (longitudinal tension). In a cast gun there comes a stage when it is no use adding to its thickness to give it extra strength. The circumferential stress near the bore is very much greater than near the outside of the gun, and to make the gun thicker does little or nothing to increase its resistance to the circumferential stress. So you see that by the middle of last century the cast gun was quite at the end of its tether. Now Lord Armstrong recognized

the fact that *wrought* iron is twice as strong in the direction of the fibre as against it. To get the full advantage of this property of wrought iron he decided to make a gun of several parts, built up one on to another, and to make the inmost part of a *coiled* iron bar, so that the fibre of the iron would be arranged circumferentially, and thus best able to resist the stress. Perhaps this sounds rather obscure; but if you re-read the sentence you ought to be able to grasp its meaning.

The wrought-iron bar was coiled by drawing it out round a mandrel, much as one might wind an india-rubber band round a pencil. Then the coil was welded, making a solid tube, and on to it were shrunk several other similar coils until the necessary thickness was attained. The gun was thus built up on the principle of "initial tensions". The coils forming the outer hoops or tubes were put on to the inner ones while they were hot. When they cooled they contracted, and so gripped and compressed the inner ones. Obviously, therefore, the outer hoops were themselves in a state of tension. Therefore, when the gun was fired the gas had first to overcome the compression of the interior and then to expand the outer layers.

Thus was accomplished a revolution in gun-manufacture. It is the only method that can give us the monster ordnance of to-day, and (though it is not safe to boast) it is very unlikely to be superseded. Many changes of detail, and of material, and of methods of forging and fixing the hoops have taken place since Lord Armstrong made his famous gun in 1856. Steel has taken the place of wrought iron, and the hoops are forged instead of coiled; while some countries, including our own, have adopted the system of making guns of tightly wound wire, which is presently to be described. But the principle of the built-up gun is the principle of every gun.

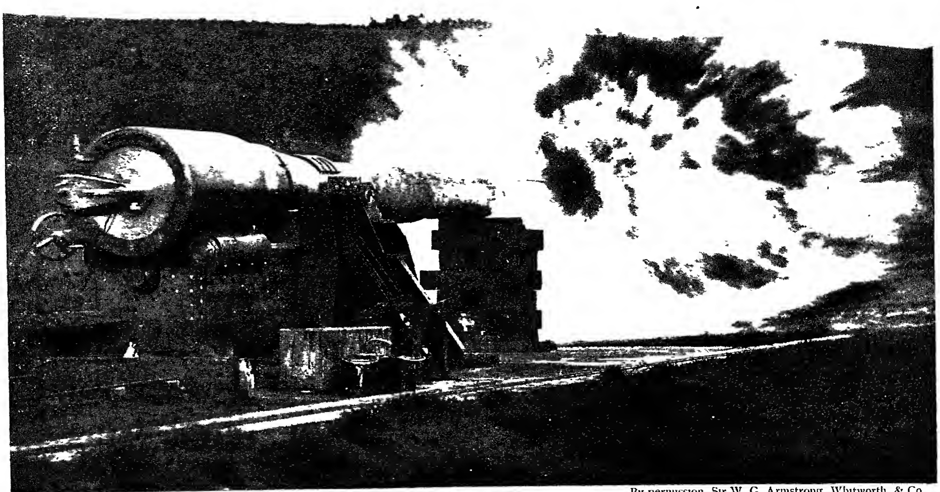
Lord Armstrong's efforts did not stop at the making of a new kind of gun. The gun we have just been describing was called the "Rifled Ordnance Armstrong", a name which fully describes its chief point of difference from its predecessors. The old cast cannon had smooth bores; the new gun was rifled. We all know what *rifle* means, and associate the word at once with fire-arms. But our grandfathers would have thought only of the "rifle, rob, and plunder" meaning, which is quite different altogether, but the only one they knew. Rifle, as

applied to gun, is a Scandinavian word meaning to cut grooves in a thing, and a rifled gun is one with spiral grooves cut in its bore. I have said that in the smooth-bore cannon there was a great loss of power due to windage; rifling, by enabling the projectile to fit the gun more closely, saved a great deal of this loss. And it did far more than that: it enabled a much heavier projectile to be used. Suppose you have two guns of equal calibre, say 6 inches: one gun fires a spherical projectile—a cannon-ball—slightly less than 6 inches in diameter. The other fires a projectile of the same diameter, not spherical, but cylindrical in shape, and 12 inches long. Obviously, if they are made of the same material, the 12-inch cylinder will be more than twice as heavy as the sphere. But if a cylindrical projectile is fired from a gun with a smooth bore it turns round at right angles to its line of flight, and its course is very erratic. If, however, you can give it a good spin before it leaves the gun, it will keep its nose in front of it and go straight to its mark. To accomplish this the gun is rifled.

Several attempts at rifling guns were tried before Lord Armstrong took up the prob-

lem, but none of the experimenters had success such as would induce the authorities to adopt his ideas. When Lord Armstrong had made his gun he cut grooves in the bore, running in a spiral fashion from the powder-chamber, where the explosion takes place, to the muzzle. The projectile was coated with lead, which, being soft, was immediately forced into the grooves as soon as the impact of the explosion set the projectile in motion. It formed on itself a male screw thread fitting into the female thread provided by the spiral grooves in the bore, and had no option but to revolve during its instantaneous passage down the gun. Thus there was imparted to it a gyroscopic motion that ensured its stability throughout its flight through space, external influences being powerless to interfere with the rectitude of its course and balance.

In modern guns the shell is not lead-coated, but is provided with a copper driving-band near its base, which answers exactly the same purpose. The grooves of the rifling are only a fraction of an inch deep; the rifling makes only one complete turn in a length of 30 calibres, and it may be wondered how this is sufficient to keep the projectile spinning fast enough



By permission, Sir W. G. Armstrong, Whitworth, & Co

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THE RADIAL FLASH OF A 12-INCH GUN

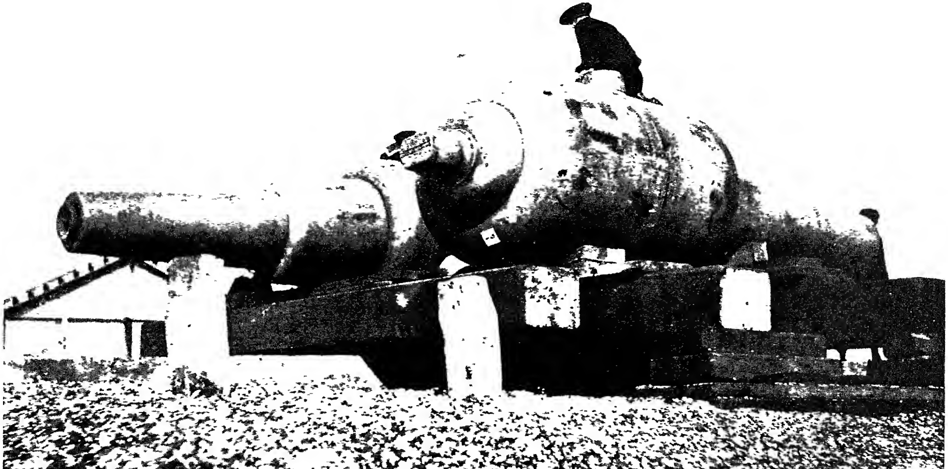

Photo: Cribb, Southsea

ONLY FORTY YEARS OLD BUT AS DEAD AS THE DODO

These old muzzle-loading guns, built for coast defence, are for sale. The Naval Ordnance Officer at Portsmouth will let them go for a song to anyone who would care to use them as "ornaments".

to ensure its travelling end-on perhaps for fifteen miles; but there can be no wonder when you think of its speed—nearly 3000 feet a second, or 34 miles a minute, or 2040 miles an hour; whichever way you like to put it, this is its rate of travel when it leaves the muzzle of the gun.

Rifled guns did not come into use all at once; the smooth bores were not finally abandoned until 1868. Yet the longest effective range of a smooth-bore gun was not over 1000 yards, compared with the range of 3000 yards of the early Armstrong guns. It was not so much the increased range that influenced the authorities as the fact that ships were beginning to protect themselves with armour, and the consequent need for heavier projectiles. Breech-loading, too, was a very long time coming into use. The early breech-loaders (the "Rifled Ordnance Armstrong" gun was a breech-loader, but by no means the first, which was made some time in the sixteenth century) were very unsatisfactory. The powder charge often exploded before the breech-block was properly closed, with, of course, unfortunate results for the gun crew.

The biggest muzzle-loader ever made for a British man-of-war was the 80-ton gun of

1875. Four of them were mounted in the *Inflexible*, a ship that distinguished itself by its devastating gun-fire at the bombardment of Alexandria. These guns were of 16-inch calibre, and fired a shell weighing 1700 pounds —300 pounds more than the 13.5-inch guns of our Super-Dreadnoughts. But weight of shot is not everything. The extreme range of this 16-inch muzzle-loader was about 7 miles—just a third of the extreme range of the 13.5-inch guns; and its penetrating power would be of no avail against modern armour-plate.

Four years after this huge gun had been made there happened a disaster that once and for all put muzzle-loading guns out of court, and caused a speedy return to be made to breech-loading. H.M.S. *Thunderer* was carrying out firing practice with her 38-ton guns when one of them burst. There were two guns in the turret, and it was proposed to fire them simultaneously. One of the guns missed fire; but in the noise and confusion caused by the discharge of the other, nobody noticed that only one gun had gone off, and both were ordered to be reloaded. One of them had thus a double charge—two 800-pound shells and two cartridges each of 110 pounds of powder. When

the guns were fired again, that with the double charge exploded, killing ten men and wounding many others. It was felt that such a dreadful mistake would be quite impossible with a breech-loading gun.

I propose to describe the breech mechanism further on, but for the moment I think it is time we returned to our ingot. Remember, it is a steel ingot. Armstrong's gun was made of wrought iron, having a breaking stress of from 10 to 23 tons per square inch, according to whether its parts were of hoop or coil form respectively. Many years later the wrought iron gave place to wrought steel, having a breaking stress of 40 tons to the square inch, nearly twice as strong as the iron; while the nickel steel we are using has (if we treat it properly) a breaking stress of about 50 tons. Presently we shall add to the strength of our gun by winding it with wire having a breaking strain twice as great as that of the steel, which we must now hurry to make into a barrel. Thus in little more than fifty years the gun-maker has been able to multiply the strength of his material by little short of ten.

We left the steel to solidify in the huge ingot mould. It is now a 50-ton lump, of circular

section, from which will be fashioned the barrel or inner tube, the foundation on which the gun will be built up. First of all, then, the ingot is lifted by a crane and taken to a saw, which cuts off a piece from each end. This is because the top and bottom of the ingot might be porous, and the gun-maker takes no risks. After this it is put into a huge machine which bores a hole right along its centre. Naturally, it objects very much; it gets so hot with anger (or the friction of the cutting tool) that streams of cold water are turned on to try to cool it. But its troubles are only beginning. The boring done, it is swung away by the crane and carried off to a great vertical furnace, wherein it is allowed to get as hot as it likes; so hot that the metal becomes ductile enough to thump and hammer into shape. It is now ready for forging, and makes its first bow to the forging-press. I always think I can see the press wink as the ingot is brought up to it. The press is such a solid and respectable-looking piece of furniture that the ingot cannot suspect it of evil designs, unless perhaps the boring-machine whispered of what was in store for it. The crane slides the poor ingot gently on to the mandrel of the press. The crane seems to be everywhere at

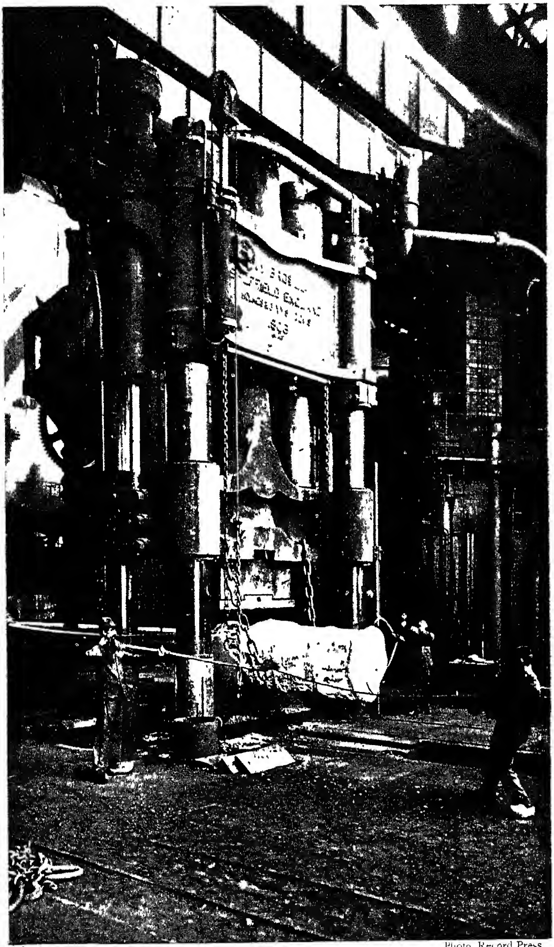

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Photo Record Press

WHERE GUNS ARE MADE

A hydraulic press of Sheffield make in a German gun factory

[illegible] Photo: Cribb, Southsea

CHARGING A QUICK-FIRING GUN

The first man holds a shell ready to slip into the breech of the gun; the man behind him has the cartridge containing the charge of cordite

once, ready to do anything. It is the foundry-man's second pair of hands. After all, you know, he must have help. He can't run about with a 50-ton lump of steel under his arm. Filled with admiration of the powers of the travelling crane, I said to him once: "How on earth did they manage to handle these forgings before cranes were invented?" The answer took a lot of considering, but it was terse and to the point: "Well, I reckon they didn't!"

On to the mandrel goes the forging, a stream of cold water coursing through its centre. Down comes the die of the press, the earth booming to the scrunch of steel on steel—Vulcan's mightiest blow outdone by a trickle of water, just water; water to drink, to wash in, to play with; water of the gentle rain and the dew spangle, forced through a pump, and held in, held in a pipe until it has become the greatest giant that slaves for man. Is there anything more wonderful than this? This water press exerts a pressure of *5000 foot-tons*, and shapes the reluctant steel as a blacksmith shapes soft iron. A little while ago men gasped to read of steam-hammers that could strike a blow of 500 foot-tons. A mere nothing! Armour-plate is made in presses having twice the crushing

power of the one now dealing with our forging.

Under the prodigious blows of the press, one end of the forging is getting longer and thinner. It looks as though it were being spoilt; but, bless you! it is good for it. I could give you a variant of "a woman, a dog, and a walnut tree", but it is not worth while. The ingot was purposely cast a great deal thicker and shorter than the size required for the forging, in order that it might be "drawn down" as much as possible. After about three hours' work it becomes too cold, and is sent back to the furnace to be re-heated. Then the press takes charge of it again, until it is the right size.

The beating the forging has had has made it hard, so it is annealed by re-heating, followed by slow cooling. Then it goes to a lathe which rough-turns it and bores it. After this comes the most ticklish process of all, the tempering of the forging. It is heated in a furnace to 1600° F., great care being taken to ensure that the heating is regular throughout. The indispensable crane hoists it out of the furnace and plunges it at once, a dazzling, frizzling thing, into a tank of rape oil. There is a great

commotion, and an extremely nasty smell. The oil is kept cool by a stream of water circulating outside it. The object of the oil-tempering is to make the steel harder and more tenacious, but there is a danger of setting up internal strains owing to irregular cooling of the forging. Therefore it is again annealed. It goes once again to the furnace, but this time is not made quite so hot, and then it is allowed to cool gradually in a bed of warm sand—a most comfortable relief, surely, after all it has gone through. The slow cooling reduces the strains induced by the oil-tempering, just as it reduced the strains set up by the forging.

The forging has finished with the furnace; henceforth it will suffer agonies in the turnery. But first of all, test pieces are cut from it. The tests are put in machines which try to break them with falling weights, and, failing in that, to twist or bend them. Men squint at them through microscopes, and if they are satisfied with what they see, well and good; but if the material fails to come up to the quality laid down in the specification, then the forging is condemned, the time spent on its making has been wasted, and the whole terrific business must be gone through again. However, *ours* is quite up to

the mark. So it is put in a giant lathe, a most wonderful machine, and revolves under a tool which takes off a paring that gradually gets thinner and thinner until a perfectly smooth and true surface is obtained. It will then be bored through the centre; and so exquisitely must these tasks of turning and boring be done, that an error of a thousandth part of an inch, though our tube may be the best part of 50 feet long, will be sufficient to spoil it. One of the most wonderful things in the whole wonderful business of steelworking is the power and exactitude of these huge lathes. The steel tool that is cutting steel will be white-hot with friction, yet it will continue its task for hours with no more apparent effort than we should show in the paring of an apple.

Our tube is to be the inmost part of a great gun. Over it will be shrunk other tubes or hoops, forged in exactly the same way as ours. In order that those outer hoops may grip and exert the requisite amount of *compression*, so as to resist the *expansion* caused by the firing of the gun, the outer surface of the inner tube must be made a minute fraction larger than the internal diameter of the outer tube. The matter is one of some thousandths of an inch, but they

have to be very carefully calculated and measured. The inner tube is set vertically on end, and the hoop or breech-piece (as the case may be) lowered over it, until it rests on a shoulder formed to receive it. This business of shrinking on the several hoops is very complicated. One end of the hoop must cool and grip before the other, so a ring of gas jets is made to play on the end that is to be the last to cool. It thus remains expanded and free to move until the other portions of the hoop have gripped. In order to ensure that the hoop shall cool from its interior, a stream of water is made to play up the gun during each operation of building up. Mind you, it is not a matter merely of fixing one tube on to another; the amount of shrinkage has to be *exactly* predetermined and *exactly* attained. The gun-maker has to be able to say: "I know, with mathematical accuracy, exactly how many foot-tons of internal pressure the gun will stand". Immense experience is required in performing the various operations, and immense plant and resources. On these, then, depend the strength and reliability of the gun. A single act of carelessness or ill-treatment is *certain* to be followed by failure, perhaps by disaster.

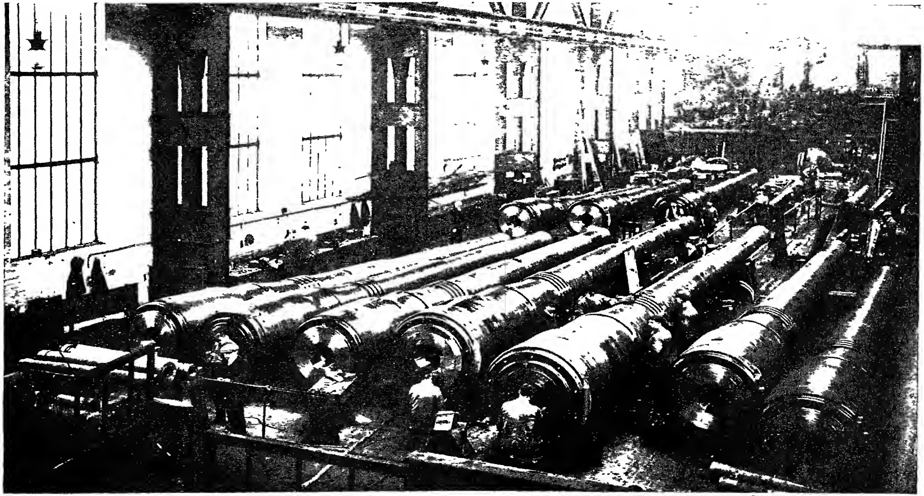
When the required number of hoops have been shrunk on, the gun is taken to the winding-machine, the object of the wire being further to strengthen it. The steel wire has a breaking strain twice that of the open-hearth steel of which the barrel and the hoops have been made—100 tons to the square inch, instead of 50 tons. It is more like ribbon than wire; it is about $\frac{1}{4}$ inch wide and $\frac{1}{16}$ inch thick, and seems flimsy stuff with which to strengthen the Colossus that has been so strenuously cradled. As the gun is revolved the wire is wound round it and tightly compressed. By means of an arrangement of weights on the winding-drums the tension of the wire is made to vary from about 35 to 50 tons to the square inch at the commencement to a great deal less than that when finishing off. In the making of a 12-inch gun more than 120 miles of wire are used. The rate of winding is (I believe) 80 feet a minute; you can soon find out for yourself how many working days of eight hours it takes to complete the winding. The wire extends from the breech nearly to the muzzle, but the number of layers varies in different parts of the gun, there being far more layers over the powder chamber, where, of course, the need is greatest. In the 12-inch

gun there will be a hundred layers, more or less, over the chamber.

When the wire has all been wound on, steel tubes are shrunk over the whole gun, which is then complete, except for the breech mechanism and mountings, which I shall reserve for another chapter. It is mounted on a temporary carriage at the proofing-grounds and fired with various charges, and its behaviour under different conditions carefully noted.

What, it may be asked, is the purpose of the wire? The answer is that it gives the gun greater strength, and, equally important, a margin of strength that enables a heavier powder charge to be used than that for which the gun was designed. The steel wire, as I have said, possesses double the tensile strength of the forged-steel tube and hoops; and another important point is that every inch of the wire can be, and actually is, tested for soundness, while no test can absolutely ensure the perfect soundness of forged metal. If a ring or two of wire gives way, or is damaged in action, the rest of the wire is unaffected, and the damage is not serious; but a single damaged hoop would probably render the gun useless. The Germans do not like our wire guns. They say they lack

"girder strength"; that is, that they have not strength to hold themselves up, but droop at the muzzle. But that is all nonsense. German ordnance firms—there is really only one that counts, Krupp's of Essen—would very much like a share of the trade the British gun-makers have built up with foreign nations. Armstrong, Whitworth, & Co., of Elswick; Vickers, Ltd., of Barrow-in-Furness; Beardmore & Co., of Glasgow; and the Coventry Ordnance Company build big guns for half the world—for Chile and Brazil, for Italy and Turkey, for China and Japan, and many another country. Germany thinks that she can "get at" some of these customers of ours by telling them that British guns are unsatisfactory; but the customers know better, and so far Germany's devices have not had much effect. British guns are probably the best in the world; certainly none are better. The big-gun industry is a very valuable one to this country; but it requires enormous capital, enormous experience, and enormous courage and initiative, and that is why there are so few private firms in the world. In emergency we can always turn out more guns than our neighbours, a circumstance which is very obviously to our advantage.



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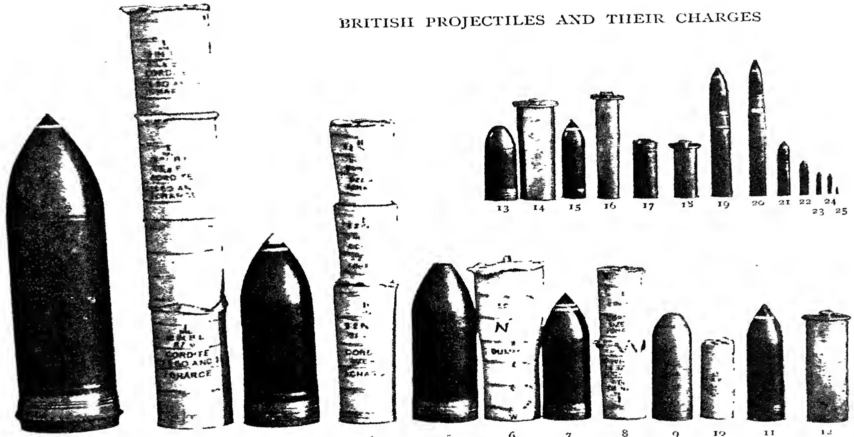
A GROUP OF FINISHED GUNS AT THE VICKERS WORKS, SHEFFIELD

BRITISH PROJECTILES AND THEIR CHARGES



The photograph shows the various projectiles used in the Navy, from the [illegible]-pound shell of the 12-inch gun to the miniature Morris tube, weighing but a few drachms. The following particulars correspond to the numbers shown against each item: (1) 12-inch shell, 850 pounds; (2) 12-inch cordite charge, 211 pounds; (3) 9.2-inch shell, [illegible] pounds; (4) 9.2-inch cordite charge, 10[illegible] pounds; (5) 7.5-inch shell, 300 pounds; (6) 7.5-inch cordite charge, 77½ pounds; (7) 6-inch shell, 100 pounds; (8) 6-inch charge, 29 pounds; (9) 5-inch shell, 50 pounds; (10) 5-inch charge; (11) 4.7-inch shell, 45 pounds; (12) 4.7-inch cartridge; (13) 4-inch shell, 25 pounds; (14) 4-inch cartridge; (15) 12-pounder shell; (16) 12-pounder charge; (17) 12-pounder case shot; (18) 12-pounder [illegible] charge; (19) 6-pounder cartridge; (20) 3-pounder cartridge; (21) 1¼-pound cartridge; (22) Electric charge; (23) .45 inch; (24) Rifle; (25) Morris tube.

Photo Cribb, Southsea

CHAPTER III

Modern Explosives

One of the chief differences between modern and ancient warfare arises out of the development of the science of explosives. Gunpowder was discovered by the Chinese in a past too dim and hoary to disturb, but the use of it in Great Britain as a propelling agent dates only from 1327, when Edward III introduced it into the war with Scotland. He called his cannon *crakeys of war*, *crakey* being a corruption of Greek. Gunpowder was used by the Byzantines in the form of rockets—not as a propelling agent—as early as the seventh century; and it was then known as "Greek fire". After Edward III took his cannon to France, and used them with deadly effect at the battle of Crécy, all Europe adopted the new method of projecting shot.

This new method, as everyone knows, was obtained by an explosion sufficiently strong to eject the shot from the mouth of the cannon;

but an explosion is, to many people even now, a mysterious thing. Explained briefly, an explosion is "a rapid combination with oxygen of various combustible substances", and the force of the explosive necessarily depends on the rapidity with which its inflammable component parts combine with oxygen. The sudden heating of gas and air causes them to expand, and thus the heavy and non-combustible part of the charge, that is to say the shot, is forced out and away from the spot where the explosion occurred. At present the only form of explosion with which we are concerned is that which takes place in the firing of a gun, and for that reason only a few of the explosives known to modern science will be touched upon. Many explosives are suitable only for blasting, and are so powerful and rapid in their action that they would burst any gun before the projectile had time to escape.

Several qualities are necessary in an explosive to be used as a propelling agent. It must, in the first place, give the greatest possible muzzle velocity with, at the same time, low and even pressure. Secondly, it must be reliable in its action, the expected results always being obtainable. Thirdly, it must not foul,

that is to say, coat or clog the bore of the gun. Lastly, its nature must be such that it can be stored without deteriorating, and carried about with safety. All these requirements are fulfilled by gunpowder, which has the additional advantages of being cheap and easily produced, and its combustion is so gradual that it does little injury to the gun. But explosives so much better suited for the purpose have been discovered of late years that gunpowder is obsolete except for salute-firing and fireworks. Consequently there is no need to enter into the complicated methods involved in its manufacture.

Since 1832, men of science have been busy trying to outdo one another in the production of deadly explosives, and recently their efforts have been crowned with the greatest success. It was in 1832 that Braconnot accidentally discovered a fearful weapon of destruction by treating starch with nitric acid. In 1838 Pelouse and Dumas applied the same process to cotton and paper, thereby producing gun-cotton and gun-paper. Nitroglycerine followed in 1847, the work of an Italian named Sobrero. It was first known as blasting-oil, and in its early years caused

so many terrible disasters that at one time its use was prohibited. It was saved, however, by the courage and genius of Alfred Nobel. To this Swedish chemist we owe the usefulness of all our modern explosives. His labours were infinite, and were often carried out in circumstances sufficiently adverse to daunt the strongest and bravest. As a matter of fact, Nobel was of a nervous temperament and weak physical health, but he was sustained in all his difficulties by an unswerving ambition. In 1866, following on years of unsuccessful endeavour, he discovered that nitro-glycerine, when mixed with an infusorial earth in which the flinty remains of myriads of diatoms abound, was perfectly safe to handle, but was an explosive twice as powerful as gunpowder and far more dependable.

This explosive he called dynamite. Yet his troubles were only just beginning. His factory blew up, his younger brother died, his father was attacked by paralysis, and his mother was prostrated by worry and sorrow. But Nobel persevered, although handling nitro-glycerine always gave him overpowering headaches—an effect it has on many people—so that he would be obliged to lie down in the mine or quarry or

laboratory and wait until the attack passed away. It took him a long time, too, to overcome the fears of his workmen and teach them that his dynamite really could be handled with perfect safety. In fact, he realized that dynamite was not explosive enough; so he set to work to find a means to make it a more efficacious compound. Ultimately he found in collodion the substance he wanted. By mixing nitro-glycerine and collodion he prepared the way for all the sensational engineering works of modern times, such as the tunnelling of the Alps and the cutting of the Panama Canal. For collodion is simply gun-cotton dissolved in ether, and when combined in the right quantities with nitro-glycerine it forms the substance called blasting gelatine. Still, however, his new creation was of no use in warfare, for the force of the explosion would tear open the strongest cannon. But a difficulty like that was an incentive to Nobel. He merely went on working and experimenting until he found the right thing, and when the time came he astonished the world possibly no more than himself. He proved that when warm nitro-glycerine was mixed with 8 per cent of gun-cotton it made blasting gelatine; but when

warm nitro-glycerine was mixed with 50 per cent of gun-cotton it made a propellent eminently suited for use in guns.

In the British Army and Navy the propellent used is called cordite. It is in principle closely allied to Nobel's discovery, so closely, indeed, that he brought an action against its makers. The verdict was not given in his favour, and as a matter of fact, although cordite has Nobel's idea for its foundation, the method of manufacture is quite different. Cordite was produced by the united efforts of Sir Frederick Abel and Professor Dewar. These gentlemen did not care for Nobel's way of warming his nitro-glycerine before adding the gun-cotton, so they worked out a new method of preparation. They found that it was possible to combine the two without heat by using an acid, and to the resulting product, which came in the likeness of a thick string of gutta-percha, they gave the name of cordite.

Cordite is made in the Government factories by a long and interesting process, the ingredients being 58 per cent of nitro-glycerine, 37 per cent of gun-cotton, and 5 per cent of vaseline. The gun-cotton is prepared in the factories at Waltham Abbey, which were estab-

lished for the manufacture of gunpowder so long ago as 1590. Here is collected all clippings and waste from our cotton-mills, and one may be forgiven for mentioning in this connection that the metamorphosis undergone by the downy covering of the cotton seed is one of the strangest things in commerce. First of all the clippings are carefully cleaned and freed from oil and grease, and are then carded and cut into uniform lengths. Then they are washed again in steam-jacketed cylinders and thoroughly dried; after which they are dipped into tanks containing strong nitric and sulphuric acids. The cotton is thrown into the tanks a pound at a time, and is kept moving to ensure its taking up a sufficient weight of acid. After dipping, it is squeezed until it only retains nine times its own weight of acid; in other words, cotton originally weighing 1 pound weighs 10 pounds after dipping. It is then washed and squeezed several times in succession, next being boiled, dried again, turned into pulp by a cutting machine, and pressed down into disks.

By this time it should have lost all trace of the acid; but, to make certain, tests are applied to it. The sulphuric acid is added only to make the cotton absorbent, so that it will take

up any water generated by the explosion, and allow the gases to have full power. This finishes the manufacture of gun-cotton, which is now ready to be put to some practical use. There is no particular danger in making the gun-cotton nowadays, but at first there were a great many serious accidents. There are still, in the factories where gun-cotton and camphor are combined to make that cheap and useful, but highly dangerous, commodity known as celluloid. Gun-cotton by itself is of no industrial use as an explosive, as it is insufficiently supplied with oxygen, and gives off very poisonous and dangerous fumes after exploding.

The manufacture of nitro-glycerine is full of great peril, and has to be performed in specially constructed works. These works are called "danger buildings", and the spot on which they are erected is called a "danger area". The houses are all built of wood, in order that, when an explosion occurs, the walls may simply fall down and the roof be lifted up whole, and no fragments fly about to damage other buildings. The danger houses are always surrounded by a high embankment of turf. The woodwork is held together by wooden pegs or brass nails, and tools are all made of bronze or brass. The

workers are obliged to wear shoes of list or sewn leather, and keep one set of clothing to wear inside the danger area and another for wearing outside.

Glycerine undergoes the first phase of its change from a harmless to a harmful substance in the nitrating-house. In this house, into which no speck of sand or grit is allowed to enter, stands a workman watching intently, through a window provided for the purpose, the movements going on inside a large leaden tank. The tank contains a mixture of nitric acid and sulphuric acid, and a thin stream of glycerine flows into it. By means of a current of compressed air the workman agitates the liquids, while a stream of water circling round the tank keeps them cool. In about thirty minutes' time the nitration is completed, and the mixture is allowed to run through lead-lined pipes to the separating-house. All the houses are built on different levels, so that the liquid runs from one to the other by its own weight.

Now follows the most dangerous part of the process. In the separating-tank the raw nitro-glycerine is washed with water to carry away the waste acids. The water, however, sets up a chemical decomposition which produces great

heat, and if the nitro-glycerine becomes too hot it will explode. The separating-tank, like the nitrating-tank, is provided with a window at which a workman stands watching for red fumes. If these appear, the watcher introduces compressed air; but if that fails to cool the mixture, he opens a tap and lets the whole lot pass out into the drowning-tank. If, however, the separating is finished without accident, the liquid runs away to the filter-house. After being drained through flannel it is collected in rubber buckets and analysed by the chemist. He may either send it back to be washed again in the separating-tank or allow it to go on to the settling-house. Here it is run into tanks, where it remains for a day or two, until the water has risen to the top and the heavy explosive has sunk to the bottom.

Thus are prepared the two main ingredients of cordite. All that now remains is to combine them in the right quantities. Nitro-glycerine is poured over gun-cotton in the right proportions, and with the addition of acetone, a solvent made from acetate of lime, a paste is formed. To this vaseline is added for the purpose of lubricating the bore of the gun and preserving it from the friction of the projectile. Lastly, it is pressed

through a machine which forms it into strips like macaroni. These strips are of varying diameters for different sizes of guns. Properly used and stored it is the most efficient and safest of modern propellents. It is almost smokeless, and can be stored in magazines at a temperature not exceeding 100° F. without deterioration.

But it has a very harmful effect on the guns, and for this reason Britain was laughed at by other Powers for using it, until two terrible accidents proved the inferiority of their own explosives. One of these was the blowing up of the *Maine* in Havana harbour in 1898, which the Americans declared was caused by the Spaniards. The Spanish-American war followed, disastrous to both nations, and it was not until the *Maine* was raised, in 1911, that it was discovered that the explosion had occurred inside the ship, and was due to the deterioration of the explosives on board her. The second was the destruction of the *Liberté*, which occurred from exactly the same cause. It has been established now that gun-cotton powders, such as were on board the *Maine* and the *Liberté*, are subject to attack by an organism which sets up decomposition. Our Navy, being

the largest in the world, carries more explosives than any other and through every shade of climate, but we have very few accidents caused by explosives. For this we have to thank Sir Frederick Abel, who by his system of heat tests has made it possible to detect the first sign of deterioration in cordite. The gun-cotton powders in use in the navies of France, Russia, and the United States are known as nitro-cellulose powders; while Great Britain, Germany, Austria, Italy, and Japan use nitro-glycerine powders.

Gun-cotton has a very important part to play in naval warfare, for it is the explosive with which torpedoes and submarine mines are charged. It must be remembered that gun-cotton, properly handled, is perfectly safe. It can be lighted with a match, and will burn as peacefully as a candle; in fact, it does not explode even if a shell strikes a torpedo and bursts in the very midst of the gun-cotton. A very complicated piece of workmanship, known as the detonator, is included in the construction of both submarine mines and torpedoes, and it is this which produces the explosion when struck in exactly the right manner. The detonator is a most dangerous

thing, one of the prominent rules of the torpedo drill-book being: "Always handle detonators with the greatest care". The deadly fulminate of mercury which it contains is one of the most violent explosives known. It is harmless when damp, but when it is dry the least jar or friction will create a frightful explosion. It is easy to imagine the risks run by the men on board a mine-laying ship laden with dozens of mines, each containing 700 pounds of wet gun-cotton. Thoroughly to understand the action of the detonator it is necessary to appreciate the subtle difference between an explosion and a detonation. To be absolutely precise, there is no difference, but the term detonation is applied to an explosion of an explosive which explodes all at once; that is to say, so much heat, or so much force, which is the same thing, is brought to bear upon the explosive that it has no time to burn gradually but changes instantaneously into gases. When the fulminate of mercury is struck, it fires at once and lights fragments of dry gun-cotton which are packed round it. These in turn fire the damp gun-cotton, and an explosion of enormous power results, the whole process occupying an irreducible fraction of time. Its

violence perhaps may be realized by noting that fulminate of mercury when fired by a blow expands to 2500 times its original size.

Gun-cotton charges work havoc simply by their own efforts. Cordite, however, is only a means to an end, the end proper being attained by the shell which the cordite ejects from the cannon. Shells are made of the hardest steel obtainable, are cylindrical in shape, and hollow. They contain a charge of powder just strong enough to open them, which is lighted at the proper moment by a fuse, and different kinds of destructive agents according to the type of shell. Thus a shrapnel shell, called after its inventor, Colonel Henry Shrapnel, R.A., is filled with bullets, which are liberated about a hundred yards in front of the target and spread out in a fan-shaped shower, the essential object being man-killing. *Common shells*, on the other hand, are directed chiefly at buildings or any solid mass, and contain a very strong charge of powder only. The most deadly of all is the *lyddite shell*, which has been in use only since 1898. Lyddite, which takes its name from the Kentish village Lydd, where it was first made, is much the same in composition as the French mélinite and

Japanese shimose. All three have picric acid as their explosive factor. Picric acid is a combination of carbolic acid with fuming nitric acid, and has for many years been used as a yellow dye. It was, in fact, an explosion at a dyeworks which opened the eyes of the general public to the explosive properties of picric acid, although men of science had already become acquainted with them. When melted it has the appearance of honey, and is then mixed with gun-cotton dissolved in acetone. The shell is fired by a charge of cordite, and when it lands a fulminator detonates it. It bursts with fearful effect. Not only does the force of the explosion shatter everything around, but a cloud of poisonous fumes is liberated, killing every living thing within its reach.

High-explosive shells, as those are called which are charged with lyddite or kindred substances, are playing a very important part in the war. We are using them, and so are the Germans and the French, and doubtless the Russians and the Austrians and the Belgians and the Japanese as well. The Germans have hurled thousands at our trenches in the vain hope of terrifying Tommy Atkins. But

Tommy will not be terrified ; and we can guess the impotent rage with which the modern Huns learn of Tommy's irreverent way of alluding to their shells. He dubs them coal-scuttles, Black Marias, and Jack Johnsons, on account of the clouds of poisonous black smoke they emit; and continues to smoke his cigarette or eat his biscuit and jam with a superb nonchalance. Yet these high-explosive shells are very frightful things and might well unnerve the bravest. We have been told that those from the German 8-inch and 9-inch howitzers form craters in the ground large enough to bury five horses. If you looked for a lyddite shell after it had exploded you would not find much of it : some of it would have been rended into fragments no larger than grains of coarse sand, and this though the steel is the strongest that can be made!

Immense pains are taken in the making of a shell. It is not merely a canister of steel to hold the shrapnel bullets or the lyddite, but a canister of perfect steel. Shells used to be made of *cast* steel, which is very hard indeed; but it is also brittle, so now they are forged from a solid ingot, passing through fires and gigantic presses and wonderful lathes and

boring-machines, much like the guns from which they are fired. They have to be very carefully tempered. An armour-piercing shell must be made intensely hard at the point so that it can fulfil its purpose of getting through armour-plate, itself intensely hard. But the walls of a shell are thin compared with the armoured walls of a ship, and it would shatter on impact; the object of the armour—to resist the shell—would be accomplished, and the object of the shell—to penetrate the armour—fail of accomplishment, unless the rear of the shell were made extremely tough and tenacious. This toughening is attained by careful annealing. Even so, the hardened point of the shell may be shattered with its own fierce blow against the armour. So it is further protected, and in rather a curious way. It is provided with a cap of *soft* metal which acts as a cushion to ease the shock, as it were, without diminishing the shell's power of getting through the armour.

The race between armour-plate and armour-piercing projectiles is long and keen; and artillerists are agreed only on one point—that neither the one nor the other has yet reached the last lap. The shells from the biggest guns can get through the hardest armour afloat if the

blow is fair and square. But probably it isn't. The blow is most often a glancing one, in which case the shell may fail to do more than blast a cavern in the armour. If enough caverns can be blasted, the task of the shells that follow after will be as easy as—well, say, winking.

CHAPTER IV

Naval Guns

EARLY in the morning of 9th August those who were asleep on the light cruiser *Birmingham* were awakened by the fire of the ship's guns. The sharp crack of her 3-pounders and the thudding boom of the 6-inch guns speed out across the pearl-grey waters of the North Sea, a horrid noise to welcome the day. The look-out man has seen the periscope of a German submarine, a mere stick ruffling the water away towards the horizon. Instantly the bark of the *Birmingham's* guns rings out, and instantly the stick, with its sinister threat of disaster, shudders and flashes upwards and disappears, struck by a shell of deadly aim. And while the captain of the *Birmingham* manœuvres his ship and dashes end-on for his hidden enemy, who can only fire her torpedo immediately ahead, the commander of the blinded U 15 makes a rapid decision. The "eye" of his boat gone, he cannot see where he is going so long as he stays under

water, and he knows that the cruiser will cut him down. Better to die in the light than in the depths; he comes to the surface. The *Birmingham* knows what is passing in his mind and is waiting, watching like the terrier for the rat. She has not long to wait. The conning-tower of the U 15 rises from the water, the door is opened and the commander puts forth his head; with a roar the cruiser's 6-inch guns welcome their prey, the submarine's conning-tower is blown to atoms, and the poisonous thing, this water reptile of man's devising, sinks to its proper home, the slimy sea bed.

A few days before the sinking of the U 15, the mine-layer, *Königin Luise*, had been sunk by the Third Torpedo Flotilla, led by the light cruiser *Amphion*. Only four shots were fired, three of which went home. The first carried away the bridge of the *Königin Luise*, the second ploughed through her bows, while the fourth blew up her stern.

And now read this extract from a letter from one of the crew of H.M.S. *New Zealand*, describing the engagement in Heligoland Bight on 28th August. It was printed in the *Times* on 9th September: "The torpedo craft had rather a hot time with the enemy in the early

morning, but suddenly we appeared out of the mist. To say that they (the German cruisers) were surprised is to put it mildly, because before they knew what they were playing, our light cruisers and destroyers worried them like terriers and plugged lumps off them. . . .

"After the action to see our innocent-looking ships leave the spot where they (the German ships) sank was a sight for the gods. Two of their ships, I am convinced, would have been floating to-day, but as our small ships gathered round them, to take off their survivors, all their flags were struck. They opened fire only to be sent to Davy Jones's locker a little quicker than they could shoot. You have heard me say, no doubt times without number, that the probable duration of a naval action (once we engaged) would be about twenty minutes. Well, we succeeded in sending some good ships and some unfortunate men to the bottom in something like fourteen minutes."

Read also this extract from another letter describing another aspect of the same engagement: "It was a fine sight to see the *Lion* demolish one cruiser. We could see her (the [German] cruiser's) shots falling short, but still the *Lion* did not fire. For fully ten minutes

the cruiser belted away without getting a single hit. Then the *Lion*, which was leading the line, hoisted 'Open fire', turned slowly and majestically round, and fixed her broadsides—once. It was quite sufficient. Up went a cloud of smoke and steam from 'the target', and when it cleared off her aft funnel was at a rakish angle, and a huge rent appeared the length of her side." The battered cruiser (having struck her flag) opened fire (in accordance with established principles of warfare!) on the destroyers that hastened to take off her survivors; so "once again the *Lion* turned, and this time fired but five shots from her huge turrets. Amidst a shower of splinters, smoke, and fire the German disappeared. We steamed over the spot where she sank, but . . . not a single living thing was to be seen."

Although I know you must be quite familiar with their history, I have quoted these early incidents of the war at sea because they show pretty clearly three things. They show that the guns of the British ships are "exceedingly excellent"; that the men who mind them know their business; and that the messages they send are not exactly of love and kindliness. It should be a source of thankfulness to every

one of us to know that, whatever dangers our glorious ships have to face from subterfuge, from the air, or the depths beneath them, when they meet the enemy face to face and gun to gun there will never be doubt as to the issue. The Germans may have better air-craft than ours and more of them, their field guns may be better—as to that opinions differ; but at sea we have the best guns and the best gunners in the world. Practically everyone admits this who knows one gun from another, except of course the Germans. We ought to be sorry for the Germans, as we should be sorry for all other self-complacent people who believe in themselves only. But I am very glad that in the matter of naval guns we are about two years in front of the Germans. This is no wild idea "out of my own head". It is out of the *Naval Annual* for 1914. Let me say it again (in the *Naval Annual's* own words this time) that it may sink in the deeper: "*The Germans appear to be from two to three years behind Great Britain in the matter of the calibre of guns*". In these days of big guns on big ships with big protective armour, that is a very big matter indeed.

The thing that is to me most wonderful about

the encounters I have just recited is the amazing accuracy of the British fire. The "scraps" were over almost before the men had time to enjoy the excitement of battle. For the British Navy as a whole the average number of hits works out at one in every two shots fired. In the annual gun-layers' tests the average, for the whole fleet, of hits to rounds fired is well over 50 per cent, and has been for some years past. The tests embrace all sorts of guns and all sorts of conditions of weather, and are as comprehensive as they can be made. In 1907 the average was only 42.70; in 1909 it had gone up to 54.12. Perhaps this doesn't convey much to you. Remember the conditions of gun-fire at sea, and contrast them with those on land. The ship from which the gun is fired is moving, and so is the target, the ship at which it is aimed. The two ships may be moving past one another, or in the same direction—probably at different rates of speed—so that they may also be drawing nearer each other, or farther apart. And there is also another kind of movement, that of the sea, which may alter the elevation of the guns with every wave.

Let us enter one of the huge gun-turrets of the *Iron Duke* to see how the guns are worked.

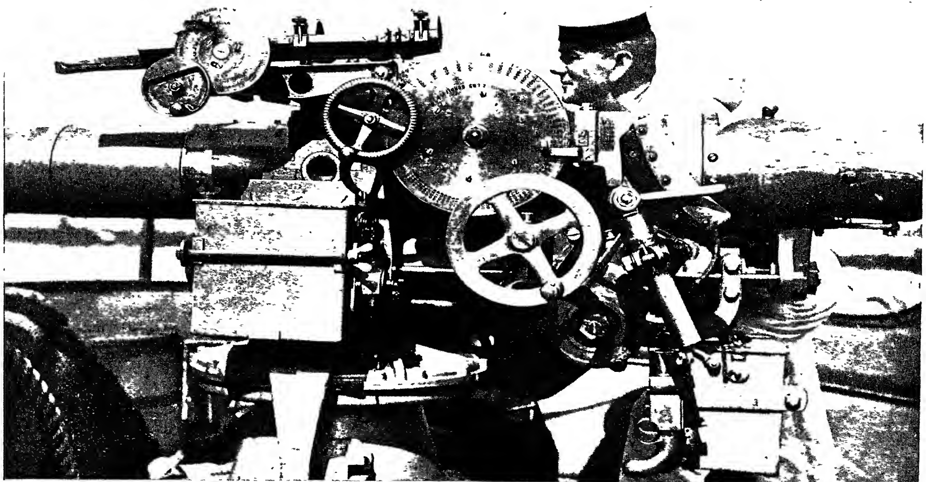


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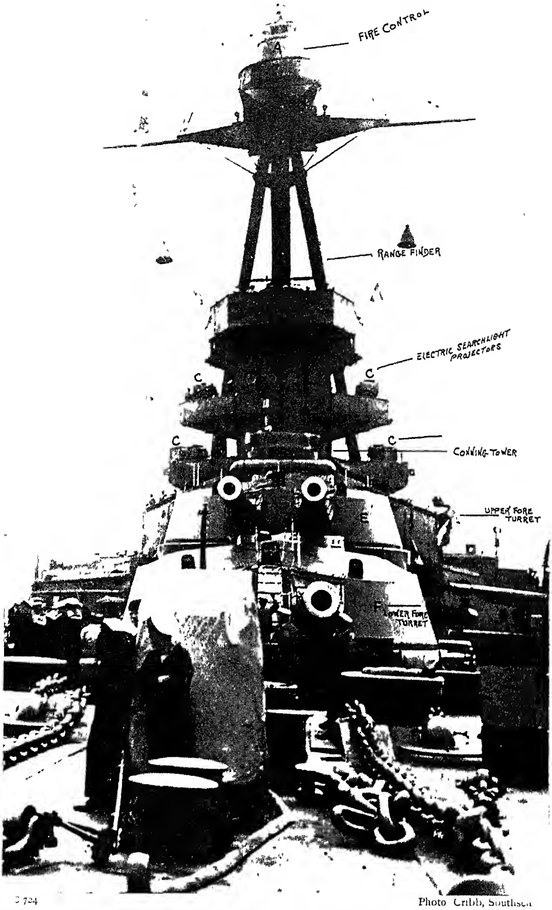
Photo Cribb, Southsea

LAYING A 12-POUNDER 8-CWT. GUN ON A DESTROYER

The photograph shows the complicated mechanism of the sighting and elevating gear



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THE FORE GUN TURRETS ON H.M.S. *IRON DUKE*

The *Iron Duke*, the Flagship of Sir John Jellicoe, Commander-in-Chief of the Home Fleet, has ten 13 5-in guns mounted in five twin turrets on the centre line of the ship. This view shows the conning tower, the range-finding station, and the fire control top. The great steel tripod mast is so strong that if two legs were shot away it could still remain standing.

The turret is the shield which protects the mechanism of the guns from damage by an enemy's shells. Its walls are 1 foot thick—12 inches of the hardest steel that can be made. The turret and its guns are fixed on a revolving turn-table which moves on a circular roller path—a thing like a toy circular railway, on which the turn-table bears by means of a great number of little rollers—the turn-table being enclosed in a heavily-armoured steel belt called a barbette. Connected to the turn-table, and revolving with it is the trunk, a great shaft leading right down into the bowels of the ship, where the ammunition is stored; this trunk contains the hoists by which the shells and powder charges are raised to the guns. This huge mass of machinery, weighing hundreds of tons—the two 76-ton guns and their mountings, the great 12-inch shield protecting them, the turn-table that supports the whole, and the trunk leading to the magazines—this consummate mass of exquisitely wrought but appallingly heavy metal can be revolved by a touch on a lever. Down in the engine-room steam engines are driving pumps that force water into a narrow space until it registers a pressure of 1000 pounds to the square inch. Hydraulic rams respond

to the gun-layer's command with force enough to move the vast weight of the turn-table, its guns and crew and all, even though the ship has a list of 10 degrees, and the balance of the great thing be quite upset. It is as gentle as a child, this beautiful force of water, and far more tractable; a most perfect example of power in harness.

Let us enter the turret. I do not suppose that anywhere, with the possible exception of the interior of a submarine, you will see in so small a space as this gun-turret such a brain-staggering conglomeration of—well, things. Things of the most weird and bewildering forms, as though some mad scientist of riotous imagination had called them into being. Things that Wells's moon-men might have devised, or his Martians; but seeming altogether beyond the grasp of mere men of earth. To this steel cabin, with its marvels of man's genius, arrayed in mystic splendour from floor to dome, and covering every inch of space, a ship's engine-room becomes a thing childishly simple, the locomotive cab a plaything for a boy. This turret, this sanctuary of concentrated essence of destruction, so small, so grimly silent—what can one say of it, how describe its splendour

and its gigantic power? Indicators, dials, sectors, pointers, scales, mazes of tubes, and clots of wondrous wheels and levers and shining metalwork of every form—oh, cunning hand that made you, and earnest hand that moves, no words of mine can desecrate your secrets!

The puzzle is to find the gun; to disentangle it from the impedimenta that embroil it. But here at last we have it, though different indeed from what it was when last we saw it in the works. It is mounted now. It has got its breech mechanism, which let us now examine. The breech-block is often called a "triumph of mechanics". Triumph of mechanics indeed! It's a triumph of almost every *ic* there is—perhaps the most perfect machine man has ever invented. Let us give credit to our friends—it was invented by the French. The breech-block is a solid block of steel, long, and slightly tapering. It was furnished with a screw thread of the requisite depth and pitch, and into the breech of the gun was cut a female thread to receive it; thus the breech screwed into the gun. But think of the time it would take to screw up the huge unwieldy lump of metal, turning it round and round laboriously until it were far enough in to resist the pressure

of the explosion in the gun! A genius thought of it, and *interrupted* the screw. He cut away portions of the screw on the breech-block longitudinally, leaving only little patches standing up here and there at regular intervals. Then he cut corresponding slots in the breech of the gun, so that, when the raised portions of the breech-block were placed opposite the smooth surface of the gun, the block could be pushed in and locked by a partial turn. *A twelfth of a turn* is sufficient to secure the breech-block of the 13.5-inch gun against a force of 69,000 odd foot-tons!

This is the system on which the vast majority of guns are breech-locked, though the Germans (and the small fry they supply with guns) have a system of their own—the Krupp sliding-wedge system. In this, when the breech is closed, a wedge is pushed in from the side, and forced home by pressure. You must understand that, whatever the method of closing it, the breech-block is hinged to the gun. Attached to the breech-block is the obturator—not nearly so formidable as it sounds. It is, in fact, quite a simple thing, just a pad of resilient metal and asbestos, whose function is to prevent the passage of fumes past the breech. When the gun is fired

it is flung back against the breech, and effectually closes any "cracks" (which is not at all the proper word) there may be. I am afraid a recital of technical details, one after another, may bore you. The most marvellous gun machinery seems to resolve itself into machinery, merely, as soon as one tries to describe it in cold blood—ink, that is. One needs the lust of the battle to make it alive; so let us suppose our ship is in action—just going into action, say—and that we are privileged to witness the working of the guns, and all that pertains to them.

Up in the conning-tower, the steel citadel placed just above the bridge, stands the captain, in touch with all the ship. Above this citadel is another, in the great tripod mast. Here is the station of some of the most important officers in the ship—the range-finders; and higher up still is the fire-control top. The range-finder is very busy with his instruments, telescopes, and wonderfully ingenious measuring-scales, and presently he telephones to the chief fire-control officer that the enemy is within range. The chief fire-control officer is a very important person indeed, for it is he who fires the guns. He cannot see them; his

station is not in the fire-control top, but in an office deep down in the ship, where he and his assistants sit surrounded by telephones and speaking-tubes and electric switches. There is something quite uncanny about him: in peace he is a delightful gentleman, in war he is a demon wielding the power of a god. He can see no more of what is going on in the light than the stokers at the furnaces, yet he fights the battle, so far as the striking force of his ship is concerned.

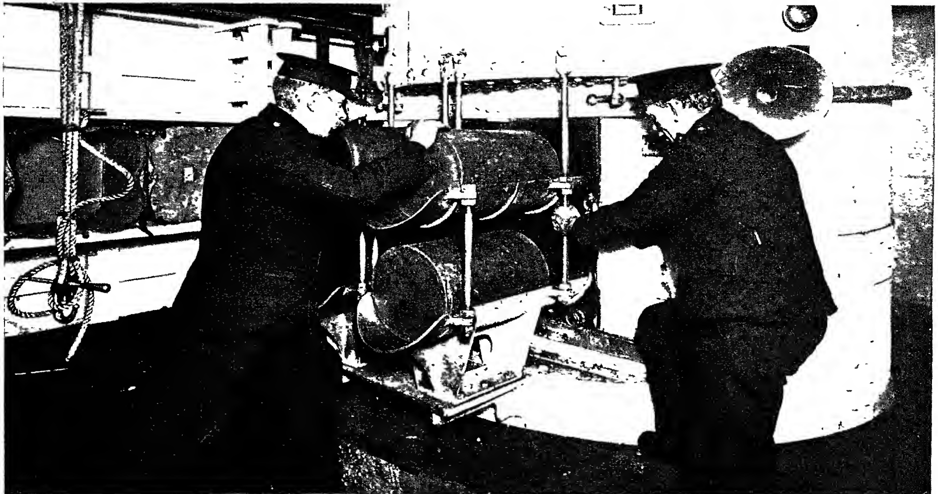
The range-finder sends down to him the message that the enemy is 9000 yards away, and says what his speed is, and in what direction he is moving. Then the chief fire-control officer does some very involved sums. Indeed, it is chiefly owing to his love for sums that he is there. He asks the captain to manœuvre the ship into a certain position; he calculates the amount of elevation that must be given to the gun to enable the shell to hit a ship 9000 odd yards away; he reckons out the exact moment when the gun must be fired, for he has three different rates of motion to consider — the motion of his own ship, the motion of the enemy, and the motion of the projectile. The motion of the enemy is an unknown quantity,

at least it is only approximately known; so is the enemy's distance. But he telephones to the turret that the guns are to be laid at a certain elevation. A man in the turret pulls a lever, and a hydraulic ram moves the whole huge turret round till the guns bear on the enemy. Another lever is moved, and another ram moves a great gun in its cradle until a pointer on a scale shows that the muzzle has reached the required degree of elevation. The gun-layer looks through his sighting telescope, on the lens of which are engraved two cross-lines. He moves the gun laterally until that part of the enemy's ship which it is desired to hit is seen to be bisected by the cross-lines. The fire-control officer presses a button at the psychological moment, and an electric current fires a primer that in turn ignites the cordite cartridges, and the great shell goes roaring on its errand.

Up in the fire-control top a man is watching to see where the shell falls. It is unlikely to hit the target; it strikes the water in front of the enemy or sails harmlessly over him. But the "spotter" has been chosen for his faculty for measuring distance, and, looking through his telescope, he marks where the shell sends

up its fountain of white water, and signals to the fire-control officer his estimate of the distance by which it fell short of the target or overshot it. Another rapid calculation, another movement of the elevating gear by the gun-layers, another touch on an electric switch, and this time the "spotter" reports that the shell has struck home. Then the guns begin to speak in couples; or the ship bends to the recoil of a whole broadside, and the ten guns let loose their pent-up energy with one accord.

Still we have not seen how the guns are worked, but only how controlled. Let us therefore watch a gun crew at their work. But first come into the shell-room, deep down in the ship, and watch the ammunition hoist at work. Naturally, a gun's rate of fire depends before all else on the rate at which it can be supplied with powder and shell, so enormous pains have been taken to make the service of the ammunition as perfect as possible. Each gun has its own ammunition hoist, which works side by side with its brother in the great trunk I spoke of as revolving with the gun platform. Down in the shell-room men are working an overhead crane suspended from a trolly on a circular path which runs all round the room. The grab



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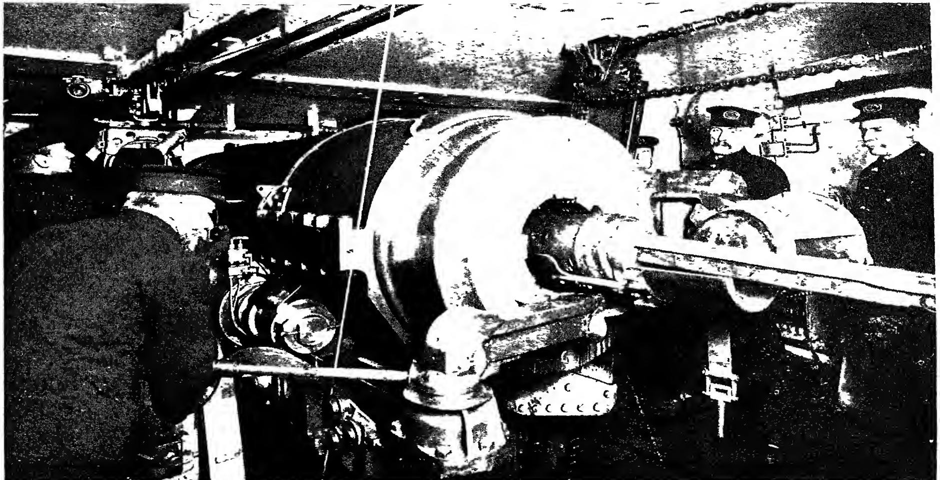
GUN-LOADING ON A DREADNOUGHT

The first process: ½-ton shells from the magazine being put into the lift.



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GUN-LOADING ON A DREADNOUGHT

The second process: after the shells have been sent up in a lift from the magazine they are driven into the breech by a mechanical rammer.

of the crane picks up a shell weighing more than half a ton (for the 13.5-inch guns) and carries it to a tray outside the cage of the hoist. The tray is pushed into the cage, a lever is pulled, and the cage goes up. It stops at the next "floor" to receive the charge of cordite from the magazine, then the hoist goes up again to the top of the trunk. Here the shell and its charge are pushed by hydraulic rams on to another hoist, which takes them to the rear of the gun. Meanwhile the first hoist has retired to the shell-room for a fresh supply.

A gunner pulls a lever and the great breech-block swings back, while a loading-tray comes into position at the open breech of the gun. And now appears a most wonderful contrivance called the chain-rammer. This is like a giant two-foot rule of many sections or "links", which are rigid in one direction, but may be folded up in the other. The rammer unfolds itself, pushes the shell on to the loading-tray, pushes it from the loading-tray into the gun, drives it home. Then it deals in the same way with the cordite, which is in four quarter-charge cartridges. Then it folds itself up and gracefully retires to rest beneath the gun until its

services shall be required for the next round. Everything is automatic. Nothing can go wrong. Each operation is dependent on the last, and cannot be performed unless and until the former has been carried out. I could not describe, nor could you understand, the amazing safety devices that are installed to prevent a single thing being done out of its time or proper order.

The gun being loaded, the "firing-tube"—a charge of high explosive that, when electrically fired, ignites the cordite—is inserted. Again a lever is moved, and the breech-block swings home and is securely locked. To do this takes four seconds. The fire-control officer presses his button to fire the gun. The gun roars, and, if it could, would fly back like some hurt Behemoth, smashing the beautiful mechanism of the turret in its throes. But it cannot. Two cylinders attached to the cradle take up the recoil and bring the monster gradually and softly to rest. The cylinders are filled with liquid that is forced from one side to the other of a piston through a gradually closing hole. And now the cycle of operations is commenced again. The breech begins to swing back, and, as it does so, an

intense jet of compressed air sweeps down the bore of the gun, blowing it clear of the "back-flash"—the burning gas that lingers after the explosion. If the breech were opened before the gun were thus cleaned out, the crew would be choked by the fumes.

Everything is done by hydraulic power: the laying of the guns, the opening and closing of the breech, the loading them. Water power is so safe, so certain and simple, that it is the supreme power for the purpose. Electricity was used for operating the guns on H.M.S. *Invincible*, but it has since been abandoned on this ship in favour of hydraulics. Of course, all the operations involved in the working of the guns can be performed by hand if anything goes wrong with the power. The revolving of a handle continuously in one direction opens the breech; the reversal of the operation closes it. But men's hands are slower and less certain than hydraulic rams, which enable a great gun to be fired at the rate of two rounds (sometimes more) a minute.

Apart from the big turret-guns, all ships are fitted with quick-firing guns of much smaller calibre. These are hand-worked entirely. The guns are exquisitely balanced, and can be

moved with the greatest ease. All have telescopic sights and scales for finding the correct elevation, and the smaller sizes have shoulder-pieces against which the gunner leans. As in the larger guns, the recoil is taken up by hydraulic cylinders. Quick-firing guns are loaded by hand, and the cartridge is contained in a metal case, the action of opening the breech automatically extracting the fired cartridge. The rate of fire naturally depends on the weight of the shell and cartridge and the ease with which they can be handled. A 12-pounder can fire about forty rounds a minute, out of which a crack gunner will make eighteen or nineteen hits. With a smaller gun the rate will be a good deal faster.

The modern battleship is simply a huge floating fort. She is designed for the purpose of hurling at an enemy as great a weight of armour-piercing shells as possible. Before the building of the *Dreadnought* in 1906, battleships were armed with large guns of various calibre. Thus, the King Edward VII class, completed in 1904–6, is armed with four 12-inch guns, four 9.2-inch, ten 6-inch, twelve 12-pounders, and a number of smaller guns. The *Dreadnought* has ten 12-inch guns and

twenty-four 12-pounders, and nothing in between. We all know that she created a "revolution" in battleship design, yet exactly why she did so is still obscure to many people.

The *Dreadnought* was a perfectly logical outcome of the development of the big gun. The gun-maker had succeeded in evolving guns of such accuracy and power and penetration that it was generally held that naval actions would be fought at ranges of about 10,000 yards—that is, at the effective range of the biggest gun. Under these conditions the "all-big-gun" battleship has obviously a great advantage over the ship with a mixed armament, since at the highest effective range she can discharge a broadside of twice the weight of the pre-Dreadnoughts, whose secondary armament of 9-inch and 6-inch guns counts for far less. The problem of controlling the fire of the guns was also greatly simplified. The *King Edward VII's* broadside comprises her four 12-inch guns, two 9.2-inch, and five 6-inch. The range has to be found separately for each calibre, and the "spotter" has considerable difficulty in distinguishing the shells of one calibre from another. If the 12-inch and 9-inch guns are fired simultaneously, the 850-pound

shell from the former makes a splash very similar to the 380-pound shell from the 9-inch, and this difficulty of telling one from the other causes delay in getting the exact range for each calibre. As a matter of fact, probably no ships less ably armed could live for long in an encounter with a Dreadnought.

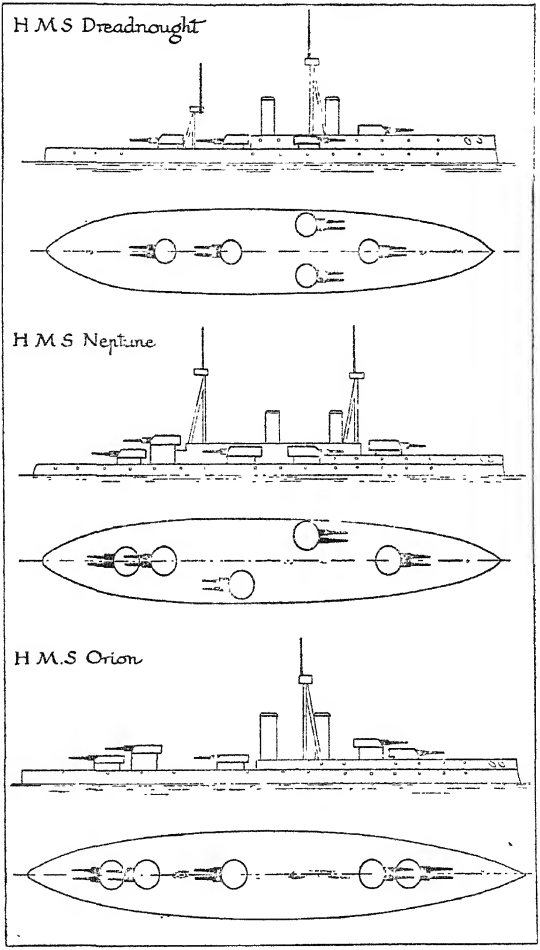
The *Dreadnought* made her appearance eight years ago. At her coming practically every existing ship was rendered obsolete, and every navy in the world found itself faced with the great problem of reconstruction. But there were many scoffers. Many naval men viewed with great alarm the complete abandonment of the secondary armament. These great guns, they urged, were soon worn out, and were quite useless after firing about 150 rounds. Remember, they said, that in the Russo-Japanese war the rifling of the 12-inch guns of the Japanese ships was so quickly worn away that at the great battle of Tsushima the fighting was done with the 9-inch guns. To these wails the ship designers made answer: We are giving you a ship so well armed, so well fortified against attack, so much simpler to control, that if you cannot sink the enemy before your guns are useless, the best thing

you can do is to sink yourselves. The *Dreadnought* was a bold experiment—how successful we all know.

She was followed, three years later, by the slightly larger "Bellerophon" class; and the boats of this class in their turn were surpassed in displacement and speed and armament by the "Orion" class. The *Orion*, completed in 1911, marked a very great advance on the *Dreadnought*, though she was on just the same principle—a moving fort armed with big guns all of one calibre (except, of course, for the torpedo-repelling armament), but bigger, better protected, and carrying much more powerful guns. I am not going to trouble you with figures about the displacement of these ships, except just to point out that the *Dreadnought*, the biggest battleship of 1906, was nearly 3000 tons heavier than the *Formidable* of 1901; while the new vessels of the "Queen Elizabeth" class, shortly to be completed, are of 9600 tons greater displacement than the *Dreadnought*. This increase in the size of the battleships has been brought about chiefly owing to the increase in the gun power and the disposal of the guns to the best advantage for fighting. This question of the

disposition of the big guns is very important, and is worth studying for a moment.

The diagrams given opposite show the positions of the guns (1) in the *Dreadnought*, *Bellerophon*, *Temeraire*, *Superb*, *St. Vincent*, *Collingwood*, and *Vanguard*, built between 1906 and 1910; (2) in the *Neptune*, *Colossus*, and *Hercules* (1911); and (3) in the *Orion* and later ships. Notice that in the "Dreadnought" class the foremost turret is on a higher deck than the remaining four turrets. Also, that eight of the ten guns can be brought to bear on either broadside, six ahead and six astern. In the "Neptune" class the guns are differently arranged. The foremost turret occupies relatively the same position as in the *Dreadnought*, but the after-turrets are mounted one immediately behind the other and immediately above it. The *Neptune* was the first ship in which this, the "superposed" turret, was adopted. Also, you will see that the turrets amidships — the broadside turrets, they are called—are *en échelon*; that is, when both are pointing in the same way, the former is clear of the one behind it. The *Neptune* can thus fire all her ten guns as a broadside, but only through a limited arc; six of the guns can



Sketch showing the Arrangement of the Guns in Three Classes of Battleship

fire ahead and eight astern. In the "Orion" class all five gun-turrets are on the centre line of the ship. The ships of this class can fire four guns ahead or astern, those behind in each case firing over the tops of those in front, as the turrets are superposed. The turret amidships has no end-on fire; but all five turrets can fire a broadside on either beam, and the guns can be trained through a very wide arc.

The superposed turret was a long time talked about before it was finally adopted. The broadside fire is so important, and the centre-line system so obvious, that it is surprising that this should have been so. But it was feared that with the huge guns that it was desired to mount, the concussion in the upper turret would be so terrific as to upset the men and the guns in the turret below. The United States naval authorities carried out experiments which satisfied them that the difficulty could easily be solved by the introduction of properly designed shock-absorbing appliances; but European Powers were not convinced, and continued to sacrifice broadside fire in order to retain an effective bow and stern fire. In 1910, however, tests were carried

out which finally settled the question whether men could work in a gun-turret with other guns in action immediately above them. The *Minas Geraes*, a magnificent battleship built in this country for Brazil, was fitted with superposed turrets. At her gun trials, the lower turret was vacated by the crew when the first round was to be fired in the upper turret; immediately after the discharge of the guns the turret was re-entered. Nothing appeared to have been disturbed, so the men resumed their stations and fired their guns simultaneously with those in the upper turret. The men were not stunned, nor was the gun machinery deranged in any way.

There is a very big difference between the 12-inch guns of the *Dreadnought* or the *Minas Geraes* and the 13½-inch guns of the *Orion* and the Super-Dreadnoughts represented by her. The 12-inch gun fires a shell weighing 850 pounds; the weight of the shell of the 13½-inch guns is 1250, sometimes more.[1] A broadside from a Super-Dreadnought represents 12,500 pounds of steel and lyddite, say 5½ tons, discharged with a muzzle-energy of 690,000 foot-tons. It is too prodigious to grasp. You can

[1] 1450 pounds in the case of the newest 13.5-inch gun.

think of it, if you like, as representing power sufficient to lift the *Iron Duke*, Admiral Sir John Jellicoe's 26,400-ton flagship, more than a foot into the air at one bound. No wonder that there were doubts and fears for the powers of endurance of the crews of the ships! The noise of the discharge of big guns is a defect that science has not been able to remedy, and gun deafness is very prevalent in the Navy, although the men plug their ears during firing.

The noise of the guns is not the worst part, however. The actual shock—one can fairly call it a blow—caused by the blast from the gun naturally tends to upset the men; it smashes windows miles away. The ear-splitting crash of one gun now and again is as nothing compared with the cumulative effect of a broadside. The plate opposite page 16 is from a photograph taken at the moment of the discharge of a Dreadnought's broadside. The camera gives a vivid impression of the force and fury of the blast; what it does not show is that the ship from which it is fired is lifted bodily about a foot by the shock of the explosion of her own guns. An engagement between fleets of modern battleships will be the most terrific inferno which mind can conceive, or

rather, fails to conceive. It will be the most nerve-racking experience that men can endure, and on their powers of enduring it may depend the ultimate issue of the battle. Nothing on land can compare with it.

In the British Navy, no more than two guns of the largest calibre are mounted in one turret, up to the present. Our desire is rather to increase the power and destructiveness of the guns themselves than to add to their number. But in other navies there is a tendency to load the battleship with guns—to overload it in the opinion of many experts. The United States battleship *Pennsylvania*, to be completed in 1916, will have twelve 14-inch guns, mounted in four turrets each containing three guns. The turrets are superposed, so the *Pennsylvania* will be able to fire six guns ahead and astern. The newest Austrian Dreadnoughts have twelve guns arranged in four triple turrets, while the French *Languedoc* class, now building, will have twelve 13.4-inch guns in three *quadruple* turrets. When you remember that every big gun added to a battleship's armament adds to the difficulties of the ship's constructor, who has to make the ship strong enough to take up the force of its blow when fired, you ought to

be filled with amazement at the manner in which he rises to the demand.

Remember, too, that in 1888, only twenty-six years ago, it was impossible to mount more than two of the famous 111-ton guns in the *Benbow*, and the other ships of the "big-gun era" that she inaugurated. These were the largest guns ever built for the British Navy, and they were soon abandoned. They were great unwieldy things of 16.25-inch calibre, throwing a shell of 1800 pounds. They had a slow rate of fire, and certain structural defects that made them very much disliked. Their life was estimated at little more than seventy rounds; but they might have been improved had it not been for the fact that their great weight presented problems which the ship designer was not then prepared to solve. The *Benbow* which was launched last year is a sister ship of the *Iron Duke*, and has a displacement of 25,000 tons, nearly 15,000 more than her namesake of twenty-six years ago; while the actual dead weight of her ten 13.5-inch guns is 760 tons—538 tons more than the guns of the old *Benbow*, the weight of the mountings being excluded in each case. The old *Benbow* cost £777,000, and was by far the most

expensive warship ever constructed at that time. The new *Benbow* has cost over two million pounds.

By the time this book is printed, probably the first ships of the *Queen Elizabeth* class will have been put into commission, if indeed they are not already playing their part in the great scheme of things in the narrow seas. The eight 15-in. guns of these magnificent vessels put completely in the shade all guns at present afloat in all the navies of the world. Their weight is very little less than that of the guns of the old *Benbow*—it ranges from 96 tons to 108 tons—and they throw a 1950-pound projectile, by far the heaviest yet obtained. And these ships will be followed next year by the *Royal Sovereign* class, armed with the same gun, but carrying five twin turrets instead of four. Referring to these guns, Mr. Winston Churchill said: "We ordered the whole of the 15-inch guns for the ships of the 1912–13 programme without ever making a trial gun. We trusted entirely to British naval science in marine artillery, to the excellence of our gun-making system, and to the quality of British workmanship. When the first of these 15-inch guns was tried, it yielded ballistic results which

vindicated, with what is to the lay mind marvellous exactitude, the minutest calculations of the designer. It is the best gun we ever had; it reproduces all the virtues of the 13.5-inch on a larger scale, and it is the most accurate gun at all ranges that we have ever had. Its power may be measured by the fact that whereas the 13.5-inch gun hurls a 1400-pound projectile, a 15-inch gun discharges a projectile of nearly a ton in weight, and can hurl this immense mass of metal ten or twelve miles. That is to say, there has been an increase of rather more than 30 per cent in the weight of the projectile for an addition of 1½ inches to the calibre. This increase in the capacity of the shell produces results in far greater proportion in its explosive power, and the high-explosive charge which the 15-inch gun can carry through and get inside the thickest armour afloat is very nearly half as large again in the 15-inch gun as was the charge in the 13.5-inch."

Perhaps you can grasp the immensity of the power of the *Queen Elizabeth's* 15-inch guns if you think of what they could do if they were applied to some use other than throwing shells—to throwing something else, in fact. They fire a shell weighing 1950 pounds; Mr. Churchill

calls it nearly a ton. Think, therefore, of something that you know to weigh a ton, or nearly—a motor car, perhaps, or sixteen people you dislike, done up in a neat bundle. Take aim at some spot with which you are familiar, ten or twelve miles from where you live. The 15-inch gun would land the car or your pet enemies on that chosen spot in less than half a minute. It would take the car, going strong on its own wheels, about sixty times as long to reach the spot; your enemies, if they were good walkers, could not get there in less, probably, than 360 half-minutes. The 15-inch gun would send them buzzing away at the rate of 1700 miles an hour. Incidentally, the trajectory of their flight would carry them miles up into the air: how many miles I could not tell you without turning up some awe-inspiring tables in the encyclopædia and working out appalling calculations—which I do not propose to do, because I should not get the answer right. But at any rate they would go miles high; or to be quite on the safe side, and not to lead you to think of miles by the hundred, let us say more than a mile high—higher than any mountain in Great Britain.

There is just one other picture I would have you keep in mind, a very grim and dreadful

one. I would have you think of the *Queen Elizabeth*, or the *Orion*, or the *Iron Duke*—any first-rate modern battleship you like—pouring out broadside after broadside in the sternest fight you can conceive. You cannot imagine the deafening noise, because there is nothing in the world like it, nor the choking smell, nor the stunning shock that makes the huge creature stagger as she vomits her tons of shells. You need not think of the blows she receives, but only of those she gives, to gain an inkling of what a terrifying thing is the sea battle of to-day.

CHAPTER V

The Guns of an Army

ARTILLERY is as necessary to an army as the rifles of its soldiers, but it was not until the great wars of last century that it came to be regarded as a separate branch of military science, having, like infantry and cavalry, special functions to fulfil. The Royal Regiment of Artillery was founded early in the eighteenth century with the object of training a special body of men, not merely to manage cannon, but to understand them. Put briefly, the object of artillery is to support infantry. Plenty of incidents in the present war have made this obvious: passages of rivers have been forced or retarded, or important positions occupied or evacuated, solely by superior artillery fire, time and time again.

What, then, constitutes the most useful form of gun? Probably the most powerful. Every nation strives to equip its armies with a gun of greater power than its antagonists'; to

provide a gun that will throw the heaviest shell to the farthest distance. The advantage of great range is self-evident; the bigger the projectile the more bullets it will contain, and so every round fired will have a higher man-killing capacity than a lighter shell. Besides these very obvious considerations other points have to be taken into account. For instance, some of the advantage attached to the weight of the shell has to be sacrificed in order to obtain high velocity. A high velocity ensures a flat trajectory, and this in turn ensures that, when the shell bursts, the released bullets fly forward almost parallel with the ground, and spread out to an area about twice as great as that covered by shrapnel from a gun of low velocity.

Rate of fire, too, is very important. Other things being equal in an artillery duel, the quicker guns will silence the slower, and the gun that throws the lighter shell will, as a rule, have a higher rate of fire. And the gun must be easily served and easily moved. In the Russo-Japanese War the Russians had by far the better guns. The Russian guns threw a heavier shell, had a greater range and a quicker rate of fire than the Japanese guns, which were of ancient pattern and badly horsed into the

C 724 Photo Cribb, Southsea

TEACHING JACK TO SHOOT STRAIGHT: THE ELECTRIC DOTTER

An ingenious instrument consisting of a miniature moving target and a pencil electrically connected with the trigger of the gun All the man behind the gun has to do is to keep his sights on the target, which is moving up and down. Every time the gun is "fired" the pencil makes a dot on a piece of white board, and shows whether or not the gun was truly aimed

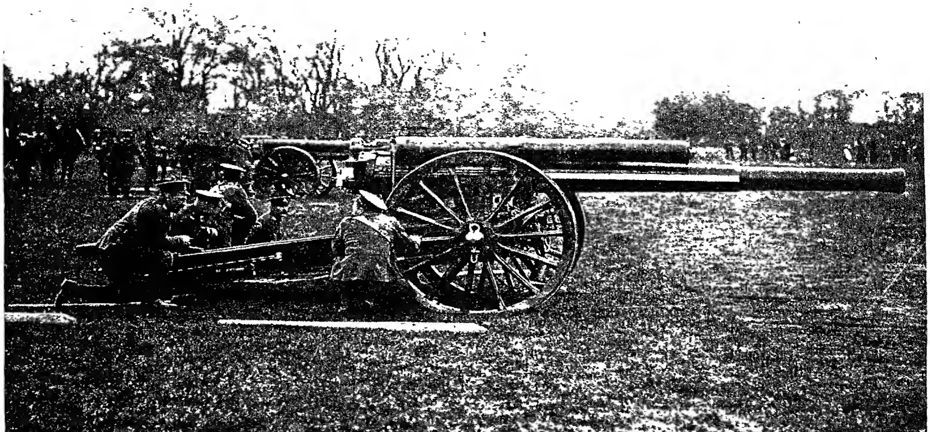


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Photo. Central News

THE ROYAL GARRISON ARTILLERY WITH THEIR 60-POUNDERS

Nicknamed "Long Toms", these 5-inch guns have increased, in the Great European War, the reputation they made in South Africa. They are used in the field and are known as "position guns" With a barrel 15 feet long they have an effective range of 7 miles.

bargain. Yet for the most part the Japanese held their own, owing to their superior gunnery; which shows that the men behind the guns still count for a great deal, in spite of all mechanical aids in warfare. Battles have never been won by machines, and probably never will be.

The ease with which guns can be moved across country is also very important, as I mentioned in Chapter I. It might be thought that guns destined to support infantry need not travel at more than walking-pace. But it may be necessary to change the gun-positions very quickly—at a "gallop", more properly a canter; and when on the move they are likely to lose time at bad places which would be no hindrance to infantry, and have to make it up afterwards. The weight of a gun is limited by the number of horses which can conveniently be harnessed to it, and not more than six horses can be used in a team. Of course siege artillery requires more horses, but siege artillery does not need to be so mobile; it is the field artillery of which I am talking now. The British field-gun, the 18-pounder, "all up",—that is, with its limber and gunners—weighs over 2 tons—43 hundredweight, to be exact. The French

field-gun weighs 1 hundredweight less, and the German gun less still.

Ultimately, no doubt, the motor will come to the rescue of the poor artillery horse, and the guns will be self-propelled; but this will not happen yet awhile. The field-pieces may be transported to the scene of action on motor-lorries, or be drawn by motor-cars along the roads. On the battle-field, however, the gun-team has still to be supplanted. Perhaps, before I go on to describe the guns that are now playing their part in the Great War, it will be as well if I say something about the different kinds that have accompanied our Expeditionary Force, and how they are distributed among the various arms.

Each battalion of infantry has a machine-gun "section" of two guns. I shall describe these guns in the next chapter. As there are four battalions to an infantry "brigade", and three brigades to a division, the division has thus twenty-four machine-guns. The artillery proper is supplied by the field-gun "brigades"; strictly speaking, machine-guns are not counted as artillery. A field-artillery "brigade" consists of three batteries, each of six 18-pounder quick-firers, there being three brigades to a

division. In addition to the field-artillery a division includes a field-howitzer brigade, of three batteries of six guns each, and also a heavy battery of the Royal Garrison Artillery. This battery consists of four 60-pounder "Long-Toms"—very formidable guns indeed. For the Cavalry Divisions, the Horse Artillery provides the guns. There are two batteries to a brigade, each armed with six 12½-pounders. The guns that accompany cavalry are capable of very rapid movement, owing to their lightness, and to the fact that the gunners ride separately, and not on the guns themselves.

The 18-pounder of the field-artillery is the principal gun of the British army. The gun used in the Boer War threw a 14-pound shell, and was generally considered to be inferior to the guns of other European Powers. The effective range of this gun was not much beyond 4000 yards, and it had a slow rate of fire. The 18-pounder that superseded it is a very efficient weapon. The actual weight of its projectile is 18½ pounds. None of the field-guns of the other armies now in conflict throws quite so heavy a shell. Though our 18-pounder is rather heavier than the foreign guns, this is not really a disadvantage. The foreign makers are

very proud of the fact that their guns are lighter than ours, power for power, and cannot be brought to see that the British gun is much stronger and capable of greater resistance to rough treatment. It has about it something of that British solidity that we admire so much in ourselves and so greatly detest in our neighbours.

One of the most important points about a good field-gun is its stability. It is not like a gun mounted on a firm foundation on a ship or in a fortress. Its carriage is balanced on the axle-tree of a single pair of wheels, and the backward thrust it sustains in firing tends to throw it out of position, so that it may have to be sighted again for the next round. Of course, such a state of things is fatal to the attainment of a rapid rate of fire, and elaborate precautions have to be taken to prevent the gun moving under the recoil. Also, the object of the shield with which field-guns are now usually provided would be defeated if the gun moved, for the gunners would have to stand back out of the way, and so expose themselves to the enemy's fire. The recoil can be, and is, checked by hydraulic buffers, but this is not enough. The difficulty is to prevent the gun

turning a somersault on its own wheels—if you have ever fired a toy gun you will know what I mean. This tendency is overcome by allowing a very long recoil, by giving the gun as low a centre of gravity as possible, and by the provision of a "spade" at the end of the trail—that is, the rear end of the carriage that hooks into the limber, and serves as a balance weight when the gun is in motion. The spade digs into the ground and gives a better hold than can be obtained by the wheels even if they are fitted with drag-shoes.

In the British guns the recoil cylinders are placed on top, this position enabling the gun itself to be kept nearer the ground. After the recoil a strong spring takes the gun back to the firing position. The presses that absorb the recoil work on the same principle as that described in connection with naval guns. The breech mechanism is on the interrupted-screw system, the breech-block itself being hinged, and opened or closed by a single action. As in all quick-firing guns, properly so called, the charge for the field-gun is contained in a metal cartridge-case which acts as an obturator, effectually closing the breech against the passage of gas. The cartridge has a fulminate

percussion-cap in its base. To fire the gun, the gun-layer pulls a lever or a lanyard attached to a trip-lock in the breech. This pulls back a striker and releases it from a catch, allowing it to fly forward and strike the cap.

Nearly all modern field-guns—with the exception of those "made in Germany"—are made with independent sights. That means that when once the sights are fixed on the target the elevation of the gun can be altered without affecting the sights at all. The gun itself is fixed on an intermediate carriage that can be moved up and down and (to a slight extent) from side to side quite independently of the gun-carriage proper. The telescopic sights are fixed to the main carriage.

Let us suppose that a battery is just going into action. A position having been chosen that affords as much cover as possible, the limbers are unhooked and disposed so as to shield the gunners, the ammunition-carts that accompany the guns are unloaded and sent back to the ammunition-column for fresh supplies, and the horses of the teams are taken away to cover. The guns themselves are placed at twenty or thirty yards' distance from one another—far enough apart to ensure that no

two guns can be struck by bullets from the same shrapnel. The whole battery will be under the control of officers stationed some distance away, field-telephones providing the necessary communication.

The provision of the independent line of sights ensures a division of labour that is very valuable. The adjustment of the gun and of the sights are two separate processes, and the man who has the task of laying the gun does not have to think about elevation, but concerns himself solely with the sighting. He has to lay the gun in direct line with the target. If the target is visible this is simple; by means of the telescopic sight the gun can be laid easily enough. But the chances are that the target is obscured in some way or other, and in that case an "aiming-point" will have to be improvised. This aiming-point may be a tree, or the line of a building; or a post may be set up in such a position that from it can be calculated the angle at which the gun must be laid in order to hit the desired object. This sounds rather involved, perhaps, but, thanks to the perfection to which sighting-appliances have been brought, the laying of the gun can be performed very quickly. Goniometric—that is,

angle-measuring—sights are fitted to all our field-guns. If one could be sure that the gun was in a direct horizontal line with the target, the sighting would be very much simplified. But it is highly unlikely that gun and target are on the same level: one may be on rising ground and the other in a hollow—in a multitude of varying positions as regards level—and whatever the difference may be, it has to be correctly ascertained. A clinometer is therefore used to set the sights in relation to the "angle of sight", that is, the inclination of the line of sight to the horizontal plane.

After the laying comes the ranging. In the case of field-artillery it is not necessary for the shell to hit the target, as it is at sea, but for the shell to burst at such a distance in front of the opposing infantry or artillery as will enable its spreading cone of bullets to do the greatest amount of devastation. This object is achieved by altering the time-fuse of the shrapnel so that it will burst early or late in its flight, as may be desired. The fuse of the shrapnel is fired by the explosion of the cordite in the cartridge.

We generally give our French friends the credit of possessing field-guns second only in excellence to our own. Of course the French

think that they are better than ours—that they are the best in the world. Probably the Creusot guns are the best, in some respects, if not in all. The British guns have advantages in solidity and capacity for hard wear that those of Creusot lack; but the French are masters of artillery, and even if they had an inferior weapon it would be more formidable in their hands than many a better gun ill-handled.

The field-guns of Creusot are famous the world over, and are as well known as those of Armstrong or Vickers or Krupp, because, like the productions of our own armament firms, they go to arm the forces of many small nations. The guns used by the Boers against us came from Creusot; and here it may be as well to explain that Creusot is a place, not the name of the maker. It is a town near Autun, in the department of Saone-et-Loire, situated in the midst of a very rich coal and iron district. There, in 1837, an ironworks was founded by some brothers named Schneider that has gradually grown until now it possesses its own coal-pits and coke furnaces, smelting-furnaces and steel-rolling mills, armour-plate works and ordnance works, and ranks amongst the greatest businesses of the kind in the world.

The French field-guns fire a 15-pound shell. They are marvellously steady, and have a very rapid rate of fire. It is said that a glass of water placed on the rim of one of the wheels of the gun will not spill when the gun is fired. I expect this feat depends largely on the quantity of water in the glass. Like our own field-guns, the French guns have an independent line of sight. The breech mechanism is quite different. The breech-block is not hinged, but is on the eccentric-screw principle. The breech is very wide, and the opening for the block is to one side, and not on the centre line of the gun. The block has a hole through it big enough to admit the cartridge, and when the gun is in the loading position this hole coincides with the breech-chamber. The cartridge is pushed in through the breech-block, which is then turned, so that the solid part of the block comes opposite the chamber and closes the gun.

The wonderful stability of the French guns is mainly due to a very long kind of recoil-cylinder. It is said that this recoil mechanism was always pooh-poohed by Krupp, who declared that it could not be successfully applied to field-guns. Instead of the spring generally

used to bring a gun back to the firing position after the discharge, compressed air is used by the French.

Artillerists have never been enthusiastic about the German field-guns, which throw a lighter shell than ours, and are rather old-fashioned. But it must be admitted that in many actions in France and Belgium the Germans have proved themselves expert gunners, quick to secure good positions and to get exact range. However, we are told that the French soldiers are delighted with what they consider the superiority of their artillery over that of the Germans. They say that the German shrapnel bursts too high, and that, although it makes a terrifying din, it does less actual damage than it ought to. Their own guns, on the other hand, sweep the ground, destroying everything on it in a wonderfully short space of time. The French soldiers boast that their gun can fire twenty-five rounds a minute, and has actually done so in recent battles. This may be an exaggeration, but the regulation rate of fire is about twenty rounds a minute. Our own 18-pounder can fire about as quickly—quicker, if need be; for Lord Roberts once said that he had seen it fired thirty times

in 1 minute 17 seconds. The French have great faith in what is called a *rafale*, that is, a "gust" of fire obtained by firing, as rapidly as possible, eight rounds from each gun—each two rounds being fired at an increasing elevation. Far more deadly than this is the "mowing" fire, which belches at an oncoming enemy such a murderous hail of shrapnel bullets that it has been calculated that 20 per cent of all men within the "mown" area, and 75 per cent of all horses, should be hit by separate bullets. If the Germans—extending in close formation—have had to face this fire, we may well believe that their losses have been enormous.

Howitzers are playing a very important rôle in the war. A howitzer is a short, light gun, capable of firing a heavy shell at a low velocity. It is always fired at a high angle, and is the modern representative of the mortar. The object of the high-angle fire is to enable the shell—which may be either shrapnel or high explosive—to reach objects that could not be hit by guns having direct fire. Thus the shells by bursting above troops in trenches can rain shrapnel upon them, or they can scour the reverse slopes of hills. The field-howitzers of our army are quick-firers, and are easily handled

and easily moved. Bigger howitzers than these are also used, sometimes in the field of battle, but more often for demolition work. The British 6-inch howitzer is illustrated in the plates opposite and facing page 108. It throws a shell weighing about 120 pounds. These guns were first used in the Boer War, when they showed their effectiveness for destroying fortifications.

Very large howitzers are in existence, but, although they are lighter than the largest kinds of siege-guns, there is usually great difficulty in transporting them to the site where they are to be used. The Germans boast of possessing the largest and most powerful howitzer in the world. This is an 11-inch gun; but 24-inch mortars have been used before now, and a mortar is almost the same thing as a howitzer. The great German howitzer, which probably helped to bring about the reduction of the forts that opposed the Kaiser's hordes in Belgium, is illustrated opposite p. 113. Its great feature is not its size, but the fact that it is far more mobile than any previous gun of the kind. The wheels of its carriage are fitted with "feet" to prevent them sinking in the ground. When the gun is being transported, two carriages are

used, each of them having the "pedrail", or caterpillar wheels, and each being hauled by a separate motor tractor; as the gun weighs many tons, horse-traction would be out of the question. The gun is divided for transport into two portions: the great barrel—that is, the business part of the howitzer—is placed on one carriage, and the mounting, the slide, the recoil cylinders, and the carriage and trail form a separate load. The latter carriage is that on which the gun is supported in action. It is drawn into position, the second carriage with the barrel of the howitzer being ranged immediately behind it. The barrel is then hauled off into its place on the first carriage by an arrangement of wire ropes and drums worked by the motor. The howitzer fires a 136-pound shell and has a very long range.

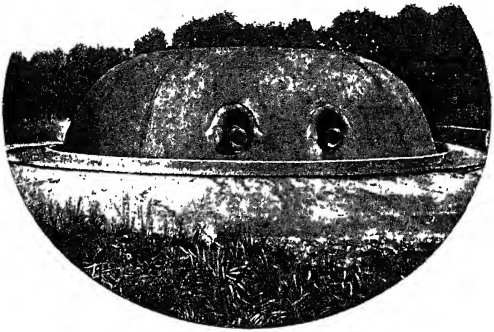
You probably read in the papers, after the fall of Liége and Namur, some very vague and surprising stories about some entirely new and stupendous German siege-guns. These monsters of destruction appeared, called into being to reduce the obstacles that blocked the passage of the German armies into France. On 24th August a *Times* leading article told us that Namur was "perfectly capable of taking

care of itself for the next three months". It fell on the very day those words appeared. Both Liége and Namur were designed by General Brialmont, who was regarded as the greatest engineer of fortifications of the nineteenth century. The forts were armed with 6-inch and 4.7-inch guns, but it is now generally admitted that the concrete and steel cupolas protecting them were unequal to resisting modern siege-guns, and the German 11-inch howitzers were quite capable of demolishing them.

There is no limit, except that imposed by the difficulties of transport, to the size of the guns that can be brought against an invested fortress. The transportation difficulty is a very serious one indeed. The guns have to be brought to their positions in as many parts as they can possibly be divided into, and then re-erected on laboriously prepared foundations. When the Japanese were besieging Port Arthur they brought the largest guns that were mounted in their fortresses at home; and a very troublesome business they found it. In some cases the Germans have been using bigger siege-pieces than the 11-inch howitzers described above. The largest appear to be of the enormous calibre of 16 inches, and were

brought up for the reduction of Antwerp. We have it on reliable authority that for their hauling the guns require the services of thirteen traction engines. Each gun is in four pieces, each piece being hauled by a "team" of three engines, while a spare engine is used for giving extra help up hills.

Guns in fortresses are sometimes made to disappear. They are placed in a deep pit, at the bottom of which they are loaded, and then raised up into the firing position. As soon as they are fired the force of the recoil carries them quickly but very gently into the pit again. Moncrieff pits, as they are called, had a great vogue at one time, but have now almost gone out of fashion, and practically all guns in forts are mounted in cupolas of steel and concrete.



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ARTILLERY *V.* FORTRESS

One of the Liége forts before and after its destruction by the heavy German siege artillery

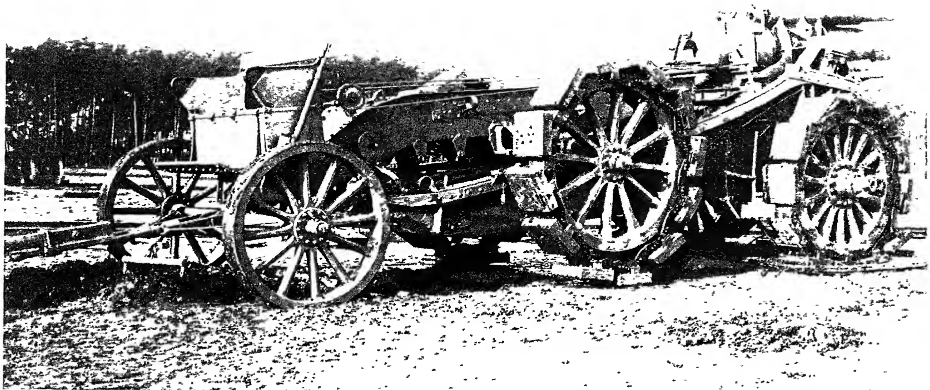

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Photo Record Press

A HEAVY GERMAN SIEGE-GUN

These giant guns proved one of the great surprises of the war. They crashed a path for the German Army through fortresses hitherto regarded as practically impregnable.

CHAPTER VI

Machine-guns

Ever since the Great War began there have been frequent references in the newspapers to the French mitrailleuses. Probably by this time you have a pretty good idea of what sort of thing this mitrailleuse is, if you did not know before. You will have seen pictures in which it is shown in various attitudes of defence and defiance—mounted on armoured motor-cars or the roofs of buildings, standing on three legs at street corners, and even thrusting out its muzzle from the steeples of churches; and you must have thought it looked uncommonly like an ordinary machine-gun—which is precisely what it is.

The mitrailleuse has a very interesting history. Its name comes from *mitraille*, the French for grape-shot, and it was so called because it poured out a stream of bullets, somewhat after the manner of grape-shot in their effect. The gun made its first appearance in the war

between France and Prussia in 1870, and, it must be confessed, helped in some measure to the undoing of the armies using it. The French had set high hopes on their mitrailleuses. They had made large numbers of them with great secrecy, and armed their infantry with them in place of field-guns. The gunners were all unskilled in their use, had no confidence in the new-fangled weapon, and were quite incapable of defending their positions against artillery that was altogether beyond their range. The mitrailleuses were soon destroyed or fell into the enemy's hands. But they were highly ingenious weapons, and the fore-runners of the modern machine-guns. Each gun consisted of an iron cylinder containing more than thirty rifle-barrels fixed in a frame. There was a special arrangement for loading all the barrels simultaneously at the breech, and for providing a continuous supply of ammunition. They were loaded and fired by the turning of a handle, and could fire about thirty rounds a minute, five seconds being required for reloading. Ten of these guns comprised a battery, which was thus capable of pouring out ten separate streams of bullets, totalling some hundred thousand in the aggregate.

Some years earlier than the Montigny mitrailleuse there had appeared the famous Gatling gun, which was used with success in the American Civil War, and was afterwards adopted by the British Navy, while it also accompanied our army in several small Colonial campaigns. The Gatling gun has, or had—for it is now obsolete—ten revolving barrels worked by a crank-handle at the side. On the top of the gun there was a drum filled with cartridges, which fell into the breeches of the barrels as they came round, the fired cartridge being drawn out by the action of the firing-lock. Each barrel was fired separately, but a gunner grinding hard enough at the handle was able to fire from 800 to 1000 rounds a minute. The Gatling gun was superseded by the Gardner gun, which had five fixed barrels; and this in turn gave place to the simpler and more reliable Nordenfeldt. The Nordenfeldt machine-gun has, like the Gardner, several barrels arranged side by side in a sort of tray, but it is worked by a lever having a to-and-fro motion instead of a crank.

By far the most ingenious of all machine-guns, and the most widely used, is that invented by Sir Hiram Maxim. It is a very wonderful

machine, and one of the most deadly weapons of war ever invented. The late Lord Salisbury is said once to have told Sir Hiram that he "had prevented more men dying of old age than any other person who ever lived". Maxim, who was born in America, early distinguished himself as an inventor, chiefly of electrical apparatus. He came to London in the 'eighties, and devoted himself to the study of guns and ammunition, of which subjects he has said that he was then quite ignorant. Yet in a short time he had evolved the famous machine-gun that has since found its way into the armed forces of all the world. The great feature of the Maxim is that the gunner has nothing to do except to keep his eye on the target and a finger on a button. The gun is entirely automatic, and goes on firing of its own accord so long as there is ammunition for it to fire. The first cartridge is inserted by hand and fired; after that the operations of loading, firing, throwing out the spent cartridge-cases and bringing into place the succeeding cartridges are performed of their own accord, the motive power being the recoil of the gun, aided by a strong spring. The cycle of operations can be kept up at the rate of more than 500 rounds

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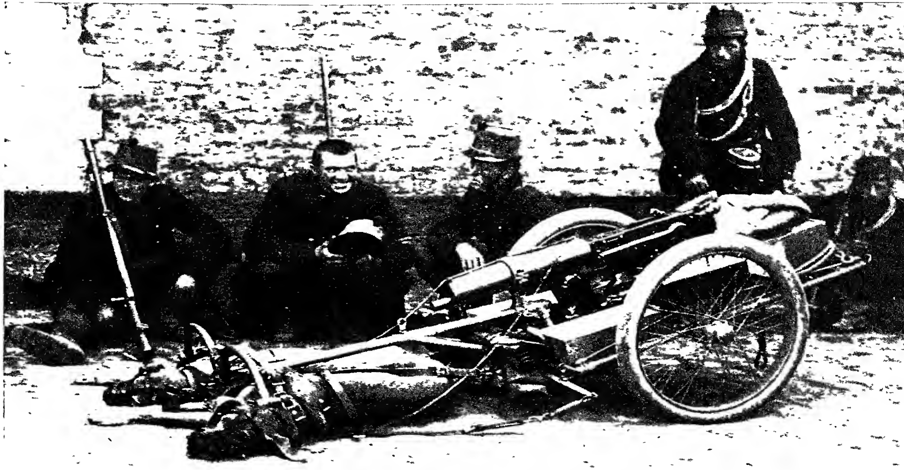
A BELGIAN MACHINE-GUN SECTION IN A CONCEALED POSITION



C 724 Photo Farringdon Co

A BELGIAN QUICK-FIRER DRAWN BY A DOG TEAM

The dog as a beast of burden is a familiar sight in Continental towns. When the war came, these wonderfully trained animals were taken out of the market carts and harnessed to mitrailleuses.

a minute, although there is only a single barrel.

The method by which a Maxim gun works is, put baldly, as follows: The discharge of the gun throws the recoiling part of it, the barrel and the breech mechanism, violently back about an inch. This causes an arm to be brought against a pawl which carries on the motion to a crank-shaft. This crank-shaft winds up a chain attached to a strong spiral spring, and so extends it. As soon as the recoil is over and the crank-shaft comes to rest, the spring contracts and pulls the breech mechanism back into the firing position. At the same time it unwinds the chain, thus rotating the crank-shaft back into its original position, ready to receive the impact of the next recoil. The cartridges are carried on a band of webbing. The motion of the crank draws back the lock of the breech sufficiently to allow the spent cartridge to drop out, while the instant the barrel resumes the firing position the spring forces a new cartridge into the breech.

The belt of cartridges passes from the feed-box into the gun from right to left, and the manner of its working (again put as baldly as I can, to save you the tedium of technicalities)

is this: In the feed-box are two movable pawls and two fixed. The movable pawls are connected by a lever to the barrel in such a way that the barrel, when it recoils, moves them from left to right. By means of a spring the pawls engage behind a cartridge in the belt, and thus the belt moves automatically towards the firing-chamber. When the barrel returns after the recoil, the pawls place the cartridge, still in the belt, immediately above the firing-chamber. So long as the gunner keeps his finger pressing on the firing-button the cartridge is fired and discharged and the next cartridge brought into place by a series of jerks so rapid that the gun seems to fire a continuous stream of bullets. Indeed, its rapidity of fire is almost a disadvantage, for there is no means of checking it, and the object fired at may be simply riddled with bullets when one would have sufficed to put "it" out of action. However, it is just as well to be on the safe side; and the gunner can fire single shots, if necessary, by taking his finger off the button. When he releases the pressure the last recoil has brought a cartridge into position, where it stays until he is ready to fire it.

The barrel of the Maxim gun has a water-

jacket to keep it cool, or, rather, to prevent it from melting! The continuous firing generates a tremendous heat. The water-jacket holds more than 7 pints, but it is brought to boiling-point when the gun has fired about 700 rounds, say in a minute and a half. A drawing-room Maxim would be a very useful present to make to those of our women-folk who are given to wanting their tea in a hurry!

The machine-gun is a very deadly weapon at close quarters, or within the range of a rifle—for it is usually of rifle calibre. We have used it largely in warfare against savage enemies, on account of its terrorizing influence. Our savage enemies in the present campaign have had more than one taste of British Maxim bullets. In the street-fighting in the little French town of Landrecies, on 26th August, the machine-guns played frightful havoc with the Germans. A British machine-gun detachment had taken up a position at the head of a narrow street. Presently a German infantry brigade advanced up the street, "which they completely filled", says the official report. "Our machine-guns were brought to bear on this target from the end of the town. The head of the column was swept away, a frightful panic ensued, and it is

estimated that no fewer than 800 or 900 dead and wounded Germans were lying in this street alone." And you may have heard how, in the early days of the war, the Germans attempted to rush one of the forts at Liége. They had made assault after assault—all of them in vain. But at length, sheltered behind a huge wall of their dead comrades, the infantry managed to creep up. Nearer and nearer they came, not heeding the ominous silence of the fort. At last they reached the glacis, the smooth, sloping bank of the fort itself, and climbed half-way up it. Then in a sudden furious gust the machine-guns on the fort swept the glacis with an appalling hail of metal, and the Germans at the threshold were rolled down, dead and dying, into the ditches below.

One of the great advantages of the machine-gun is its portability. It is generally mounted on a tripod-stand capable of adjustment to any height or angle. The gunner sits astride the hind leg of the tripod, which provides a perfectly steady seat both for him and for the gun. The legs fold up for transport, and as the whole gun, lock, stock, and barrel, weighs only 36 pounds (in the latest Maxim pattern), it can be carried about quite easily by a couple of men, or

loaded on the back of a horse or mule, or run from place to place in a motor-car, or, as in the case of the light Belgian machine-guns, hauled by dogs. One of these Belgian guns is illustrated in the plate opposite p. 117. It is a remarkably light weapon, of less than half the weight of an ordinary Maxim, and is mounted on a little carriage with pneumatic tires. On going into action it is taken off its carriage and fixed on a tripod. Besides these special light "Berthier" machine-guns the Belgian troops are also armed with Maxims of ordinary size.

Some of the German machine-guns are mounted in rather a peculiar way. Instead of the usual tripod mounting, the guns have a miniature carriage with a yoke and a pair of very small wheels. Although a machine-gun can be mounted on its tripod in a very short space of time, it is held that one with a permanent mounting, which is small and light enough not to interfere with its transportation, has an advantage in emergencies. These German guns are so low that the barrel is only a few inches above the ground, and the gunners lie down to fire them, a shoulder-piece being provided for their convenience.

Cavalry divisions have their machine-gun

sections as well as infantry, though military experts differ greatly as to the value of machine-gun fire in cavalry operations, some holding that it is very high and others that it is not of much account. But, in any case, whether for infantry or cavalry, the great value of the machine-gun lies in the high rate of fire of which it is capable. Our own military authorities estimate that a Maxim gun is equal in efficiency to the combined firing efforts of about a hundred soldiers, at a range that is exactly known; that is, at a range up to about 2000 yards some hundred riflemen would be required to do the enemy as much damage as a single machine-gun which has managed to get its fire exactly on the target. As a matter of fact, machine-guns are never used singly if it can be helped. There comes a point when the gun must be allowed to cool down, and then a gun in reserve can come in to maintain the deadly stream of bullets.

The French claim for their machine-guns a much higher "fire-power" than we do for ours. They say that it is equal to from a hundred and fifty to two hundred rifles at an exactly known range. This does not mean that our guns are inferior, but that we prefer to take a low

estimate of the theoretical damage a machine-gun can inflict on an enemy, while our allies are far more sanguine. The French do not use the Maxim, but the Hotchkiss machine-gun. This is a very wonderful weapon, working on quite a different system from the Maxim. It is purely automatic, but instead of the force of the recoil the Hotchkiss gun makes use of the gases of the explosion of the cartridges to maintain the loading and the firing.

The Hotchkiss gun has its barrel fixed to a frame which contains the breech and firing mechanism. Attached to the barrel, on its under side, is a tube which is closed except for a small opening connected with the barrel. This opening is under the muzzle, and when the gun is fired some of the gas flashes through it into the tube and drives back a piston contained in it. A lug on the piston compresses a spring, when it (the piston) is driven back; this puts the breech mechanism into the firing position again. The pressure of the gunner's finger on the trigger releases the spring, which pulls the piston back into its original position. Thus the cycle goes on; the piston, first pushed backwards by the explosion and then pulled forward by the spring, performs all the processes

of loading, firing, and reloading the gun at the rate of from 500 to 600 rounds a minute. It is very simple. To be sure, its simplicity and the fewness of its working-parts are first among its advantages over other machine-guns; but no written description, unaccompanied by working drawings (which I am quite sure you would find it hard to follow if you had them before you), can give you an idea of the mechanical beauty of the Hotchkiss gun, or, for that matter, of any other automatic gun.

The cartridges for the Hotchkiss gun are not served up on bands, as in the Maxim, but are in metal feed-strips, each containing thirty. They are fed into the gun by a complicated arrangement of gear-wheels and cams and clips worked by a spring. Fresh cartridges are placed one by one in front of the breech, ready to be pushed in as soon as the fired cartridge has been ejected. The spent cases are thrown out at the side of the gun by a claw extractor. The gun is not water-jacketed, but is air-cooled by having ribs or "fins" on it, after the manner of a motor-cycle engine.

The Austrians have a machine-gun of their own, the Schwarzlose. This is worked by means of the waste gases, like the Hotchkiss,

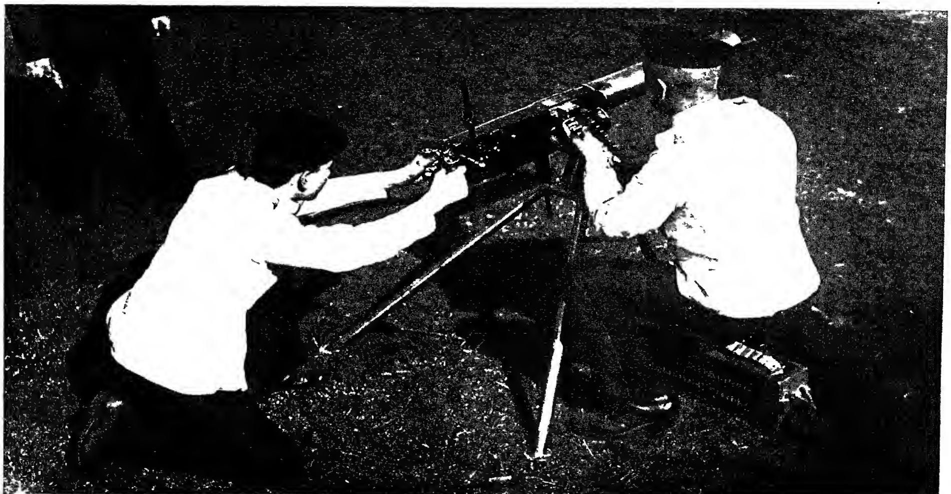


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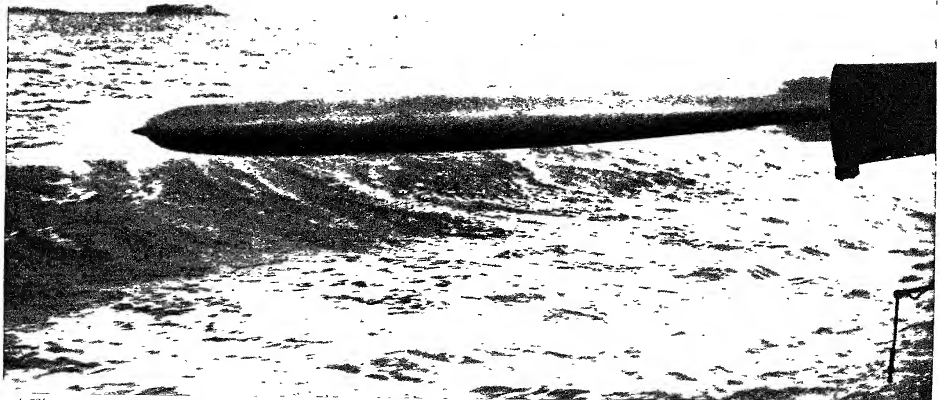
Photo Cribb, Southsea

A MAXIM GUN OF THE ROYAL MARINE ARTILLERY

The 7½ pints of water surrounding the barrel are raised to boiling-point in about a minute and a half.



C 724

Photo H Symonds & Co

THE MOST WONDERFUL WEAPON OF DESTRUCTION· A TORPEDO PHOTOGRAPHED IN THE ACT OF LEAVING THE TUBE

but is loaded by cartridges in a belt, like the Maxim. Its advantages are its strength and simplicity: there are only ten working parts.

The machine-guns almost exclusively used in the field fire rifle-bullets, but larger and more powerful sorts are made on one or other of the principles I have described. The larger the projectile the slower the rate of fire, and the big machine-guns have not great advantages over the small hand-loaded quick-firing guns. Our own "pom-pom", so called from the noise it makes, is an automatic gun of Maxim pattern which fires a 1-pound shell. At one time machine-guns were largely used on war-ships for repelling torpedo-boats, but they have gradually been giving place to guns throwing a much heavier shell. The battleships of the "Queen Elizabeth" class carry no gun smaller than a 6-pounder.

CHAPTER VII

Torpedoes and Torpedo Craft

LONG before there was any thought of a self-propelling torpedo, people were familiar enough with the word, which comes from *torpere*, to be stiff. If they ever thought of it, which is highly unlikely, it was as an instrument by means of which ships or houses or people could be blown to smithereens with a minimum of trouble and expense. You have heard of an "infernal machine"? Well, a torpedo was an infernal machine, and it was only very gradually that a specially maritime significance came to be given to it. An infernal machine was, practically, anything that blew up to order, whether on land or under the sea. Later, when people talked of infernal machines they meant the things we now call submarine mines, and a torpedo was a genial little fellow you carried about with you, and attached (when you had the chance) to some ship whose presence offended you. It was quite a simple dodge; so delightfully ingenious that it might

have originated in a lower-school common-room.

All you had to do was to provide yourself with a boat—a steamboat for preference, as you might have to show a clean pair of heels—and a forty-foot pole. You rigged up the pole so that it projected beyond the bows of your boat. You had the in-board end of it in a crutch, so that you could swing it some eight or ten feet under water when the time came. To the outer end of the pole you fastened the torpedo—a canister of gun-cotton with a primer connected with an electric battery. Then you waited for a dark night. This given you, you sailed up to your enemy, as calmly as though you were going to pay a formal call, switched your pole with the torpedo under water, and manœuvred to get it right beneath the enemy's bottom. Then you let fly. The chances are that the thing wouldn't go off, or that, if it did, you went with it—and provided quite a fitting climax to the whole escapade. Sometimes it worked quite nicely, as in the American Civil War, when several ships were sunk or damaged by its use—though people laughed at the "spar" or "outrigger" torpedo, as it was called, and said it was impracticable. The last time it was effec-

tively used (so far as I can discover) was in the French war with China in 1884, when a small Chinese war-ship was sunk by its means. The disadvantages of the spar torpedo are so great and so obvious that I am sure I needn't enlarge on them; and yet I should not care to bind myself to the assertion that it does not still form part of the equipment of most navies—I believe it does. It is simple, and if you can be quite sure that the crew of the ship to be removed are all dead, or drunk, or asleep, it may be safe enough. But the mechanical torpedo is the only sort that is worth counting nowadays.

Closely connected with the development of the torpedo has been the development of the submarine. It was the difficulty of carrying the horrid thing above water to its destination that led men to attempt to evolve a boat that would enable it to be fastened to a ship's bottom without being seen. The idea of a submarine boat that would take the torpedo to its prey was a good deal earlier than the idea of a self-propelled torpedo, as I shall show in the next chapter; in short, the spar torpedo demanded a submarine to carry it. (I know some think that the submarine is quite a new-fangled affair, just finding its feet (or its fins) in the present war.)

How is it, then, that while we build only a few submarines each year we count our torpedo-boat destroyers by the hundred, that every battleship and cruiser is provided with torpedo-tubes, and that we have a large number of torpedo-boats whose one aim and end is the firing of torpedoes? Clearly, it is not considered that the submarines perform this duty better than any other class of boat. The fact is that the torpedo has gone ahead of the submarine, and that the submarine has been obliged to change its sphere of usefulness. It still fires torpedoes, but it will fire them only when no other type of craft is able to do so. It seems that at the present time the submarine's sphere of action is extremely limited. The torpedo, on the other hand, has expanded its influence amazingly since its inception. The following table, taken from the *Naval Annual*, shows the esteem in which the respective Powers now at war hold the various types of torpedo-craft:—

	Destroyers.	Torpedo-boats.	Submarines.
Great Britain	238	70	96
France	87	153	93
Russia	141	25	43
Total for Allies	466	248	232
Germany	152	47	39
Austria	19	85	14
Total for Enemy	171	132	53

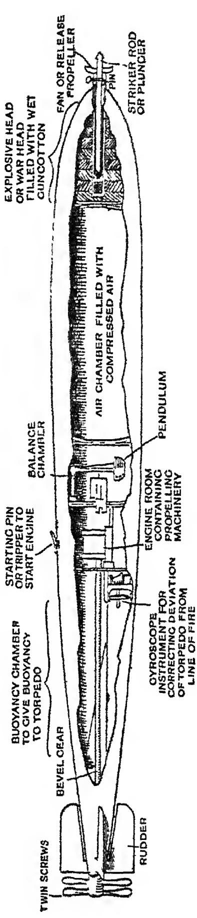
The modern torpedo—I was going to say Whitehead torpedo, but I believe it goes by another name now—is a veritable Pocket Marvel. The breech mechanism of a big gun is called a "triumph of mechanics", but I think the torpedo beats it. The steel[1] shell of a "baby" is chock-full of wonders—ingenuity in essence.

In its largest and latest size it is only 21 inches in diameter and something over 20 feet long. Yet it contains enough power in its own inside to take it through the water at a speed of 41 knots an hour (a knot is $1\frac{1}{7}$ mile) for the first 4000 yards of its journey, and at about 27 knots for another 4000 yards beyond. Its cost varies from £600 to £700, a figure which should give you some idea of its complicated "innards". Let us take a peep at these, to see what they are like and what they are for. It must needs be a surreptitious peep, because "baby's" nurses have a deep-rooted distrust of strangers, and keep them severely at arm's length; which I am sure you will admit to be the most correct attitude in these days of Peeping Toms of all nations. I wish we could send the whole hateful crowd of spies to Coventry and intern them in that salubrious

[1] Sometimes it is phosphor-bronze, and occasionally aluminium.

midland town for their health's good, and ours.

Here is a diagram that may help you to follow what I have to say. You will see that the artist has very kindly divided the torpedo up into compartments for you. These compartments are all genuine — that is, they really exist; but you must not suppose that the artist has put in all there is inside them. There is not room in his drawing, nor in his head, for everything that a larger sheet of paper (and a clearer brain) might have shown, had he looked at a torpedo hard enough. He gives us the vitals, the torpedo's lungs and heart, as it were, clearly enough; and so, instead of being captious, we ought to



The Interior of a Torpedo

be grateful that he has not sought to confuse us with a lot of pipes and "odds and ends".

First of all then (looking at the drawing) we have the head, containing the charge of explosive which all the rest of the torpedo simply serves to carry to its destination. This is the doom of the war-ship that is hit by it; no ship's bottom can withstand the explosive force of 330 pounds of wet gun-cotton, bursting in immediate contact with the plates, and 330 pounds of wet gun-cotton is contained in the first compartment of the 21-inch torpedo. Why wet gun-cotton? Simply because it explodes with as great a force as 330 pounds of dry gun-cotton when it is detonated, and is far safer for the torpedo-crew to handle. Immediately in front of the nose of the torpedo you will see a little knob—this is the striker of the pistol. Crack! goes the striker against the enemy's side. The violent blow drives it against a detonator of fulminate of mercury, which it ignites. You may remember that I told you in Chapter III that this fulminate of mercury expands to about 2500 times its own bulk when it is heated by the pressure of a blow. Now you can understand that this expansion of the fulminate, this terrific effort to

get free from its confined space, must cause an enormous pressure to be exerted on the body surrounding it. This body is a primer of dry gun-cotton, tightly packed, and extending into the main charge of wet gun-cotton. The pressure (strictly the *heat* of the pressure) of the first explosion causes the explosion of the primer, and this in turn explodes the main charge. Thus there are really three separate explosions,[1] yet to all intents and purposes they are simultaneous, and the cataclysm occurs at the instant when the torpedo strikes the ship's side. The explosion is colossal, like a bolt from the sling of a god. Nothing can withstand it. It tears steel plates like rags, and breaks a ship's back at a wrench. True, a great battleship may be torpedoed and not sink, for the most elaborate pains are taken to divide her bottom into a multitude of little boxes, each sealed and separate. But her lower part will be torn to ribbons, and at the least she will suffer a great loss of buoyancy. Smaller ships are twisted inside out, and the mine disasters in the North Sea—the mine is the same in effect—and the sinking of the *Hogue*, *Aboukir*,

[1] More properly detonations. I am afraid that if you do not already know the difference I should only puzzle you in trying to explain it.

and *Cressy* show us that the ship that is struck is stricken indeed.

I remember reading a story (by a good author, more's the pity!) of the torpedoing of a cruiser, in which the torpedo was made to *penetrate* the ship. It might have happened to a paper ship, not to a sterner sort. The torpedo has no power to penetrate anything but water, nor has it need to. There was talk some time ago of an American torpedo that was to be fitted with a gun, which, when it struck the ship, was to fire a shell into the bowels of its victim. But it was only an American torpedo, so I shall not talk further about it here.

Perhaps you are beginning to think that a torpedo, having its head so filled with hasty impulses, must be a dangerous fellow to handle. Indeed, the danger is so obvious that it is scarcely necessary for me to tell you that great pains are taken to keep it cool. An unrestrained torpedo, even asleep in its crib, would always be holding its pistol at the brains of those around it. An accidental blow against the striker, and—well, you can imagine the result! The striker, therefore, is so arranged that it cannot strike until its time comes. Attached to it is a little fan which is screwed up against the

"whiskers". The fan acts like a bolt of a nut, holding the striker securely in place. It cannot move one way or another. But when the torpedo is launched, the water streaming past the fan causes it to revolve, and as it revolves it naturally unwinds along the screw-thread; when the torpedo is a safe distance from the ship the fan falls off altogether and the striker is free. Nearly free, at least; for behind it is a pin which has to be broken before it can reach the detonator. When it reaches its destiny the blow is sufficient to break the pin, but an ordinary, casual knock, such as it might get in handling, would not be sufficient.

Let us move on to the next compartment, called the air-chamber. I am afraid there is not much to be seen here—it looks very empty and uninteresting; but it is highly important, and provides the motive power for the torpedo. Air is pumped into it until it reaches a pressure of 2000 pounds to the square inch. Probably these big figures do not convey much to you; but they may grow more significant if you bear in mind a few things with which such a huge pressure can be compared. The pressure of the air around you—assuming you live not much above sea-level—is 15 pounds to the square

inch. If you went into a tunnel where men were working in compressed air, at, say, 30 pounds to the square inch, behind a Greathead shield, you would probably feel very unhappy, your nose would begin to bleed, and you would have a headache. After you had been subjected for a little while to an air pressure of 100 pounds you would be quite unconcerned, for you would be as dead as mutton. A big locomotive is driven by steam at a little more than 200 pounds to the square inch.

Perhaps you think that, with such a big air space in its middle, a torpedo must be nice and light; in which case you are much mistaken. A moment's reflection will tell you that the more you compress air the heavier it must become. As a matter of fact, the torpedo, when its air-chamber is fully charged, weighs, I should say, *from 70 to 100 pounds more than when it is empty*. If the charged air-chamber happened to burst near you, you wouldn't know the difference between an air explosion and a dynamite explosion.

The next compartment is, I think, the most wonderful in the whole wonderful machine. It is the balance-chamber, and it maintains the depth at which the torpedo runs through-

out its course. Suppose a torpedo is fired from a torpedo-tube above water: the tendency would be for it to go down and down at the angle at which it was expelled, until it reached the bottom. This tendency is overcome, and the torpedo kept at a constant and predetermined depth in the water, by two very ingenious appliances. The first is a hydrostatic valve, the second is—a pendulum. Let me describe the pendulum first. It is a delicately pivoted weight, swinging in the line of the torpedo's flight, and connected by rods with the horizontal rudders outside. When the torpedo is inclined to go head downwards the weight swings forward, throws the rudders up, and so brings the torpedo upwards again. If the torpedo has any idea of sitting on its tail, the weight swings back, the rudders are deflected and the torpedo's stern must come up. Thus, whatever happens to interfere with it, it is bound to keep on an even "keel". The hydrostatic valve is connected with the arms which hold the pendulum levers, and acts in concert with them. It depends for its action on the pressure of the water. A spring adjusted to the required depth holds it in its place. If the torpedo shows a wish to go below that

depth, the spring is forced in by the pressure of the water, and the rods connected with it elevate the rudders. In this chamber, too, are placed the several valves that regulate the supply of air to the engines, which are lodged in the next compartment. They are marvellous little things, these engines that drive the twin propellers with speed and power enough to send the torpedo spinning along at little short of fifty miles an hour. They are no bigger than toys, and for their size are far and away the most powerful engines in the world.

There is now only one compartment left, if we exclude the tail, which contains only the gearing for the propellers and the connections for the rudders. This last compartment is the buoyancy chamber, which serves to give the torpedo the proper buoyancy. We might pass it by except that it contains one very important item of the torpedo's outfit, the gyroscope that keeps her straight on her course. The gyroscope was not added to the torpedo until 1896, but immediately it increased its efficiency enormously. When a shell is fired from a gun its velocity and its rotation about its line of flight keep it straight to its course; it has, in fact, a gyroscopic motion, which keeps it safe from

interruption. The torpedo has no such help. It is pushed, not shot, from its tube, with force just sufficient to take it clear of the parent ship, and it has no rotary motion. In theory it ought to keep straight to the course designed for it, and is fitted with rudders which aim to ensure this, but in practice it was found that several causes tended to disturb the accuracy of its flight—as, for example, the shock of striking the water. The gyroscope keeps it accurately on the course on which it is destined to run. Now I am not going to attempt a dissertation on gyroscopic motion. In these days, when you can buy a gyroscopic toy at a village store, almost, and we all talk of gyroscopic monorails that are to hurl us across country at prodigious speed, and long for the day when steamboats will have anti-rolling gyroscopes, everyone ought to be familiar with its properties and nature. Probably, too, you know a good deal more about the composition of rotations than I do, and would make a fool of me before I had got out a dozen words. No, sir! The gyroscope, spinning away for dear life in the buoyancy chamber—set in motion, you must understand, by the releasing of a spring as soon as the engines start—works a complicated

arrangement of levers connected with the vertical rudders of the torpedo, and keeps it straight.

Let us change the subject for a bit, and take a look at the craft from which torpedoes are mostly fired. The torpedo has one great disadvantage. It is slow. The fastest torpedo travels only at a rate of between thirty and forty knots an hour or, at best, a little over the latter rate; that is to say, that quite possibly the ship at which a torpedo is directed may move more than a mile in the time taken by the torpedo to make its way through the water. Of course, the torpedo captain has every facility for finding the range and reckoning the speed and direction of his target; but, even so, it is a much more difficult business to send a torpedo straight home than a shell from, say, our big 13½-inch gun, which travels 3000 feet in a second.

It is of course true that a big battleship is practically defenceless, except for its nets, which are of doubtful value, against the attacks of submarines and torpedo-boats; but for its protection it relies upon the services of swarms of torpedo-boat destroyers, which spread out around it like a fan and keep offensive torpedo-

boats at a respectful distance, even if they do not actually have a chance to sink them.

Torpedo-boats and torpedo-boat destroyers are the fastest of our naval craft. Destroyers are the faster of the two, and can attain a speed of 40 miles an hour. The boats are of necessity wonderfully handy, and can twist and turn with amazing quickness. In construction and equipment they are unique, as they have a unique purpose to fulfil. The torpedo-boat is designed to be able to creep up within range—nowadays torpedoes are effective at 8000 yards—fire its deadly tools, and then scuttle away again before the enemy's guns have been able to get at it. It makes such a small target, and travels so swiftly, that a battleship's guns are quite at a disadvantage. This is where the destroyer is useful, for its duty, as its name implies, is to chase and sink the intrusive torpedo-boat. Obviously, when a destroyer is chasing its natural prey their natural weapons are useless. The torpedo-boats have no tubes in the stern, and it would be sheer waste of time and energy for a destroyer doing 35 knots to discharge a torpedo doing almost as much. For such situations both boats are provided with guns.

The forerunner of the destroyer was the

catcher, which was very popular with the Admiralty during the 'eighties. Unfortunately, although the catchers were tried over and over again during manœuvres, they never succeeded in catching anything. The catcher was too large for her work and could not make sufficient speed to overtake the tiny torpedo-boats. The destroyers are little bigger than the boats themselves, and by cramming into them engines capable of 25,000 horse-power a tremendous pace is obtained. Both classes of boats are built of the thinnest possible material, the walls being so thin that if one leans back against them an audible *bonk* results.

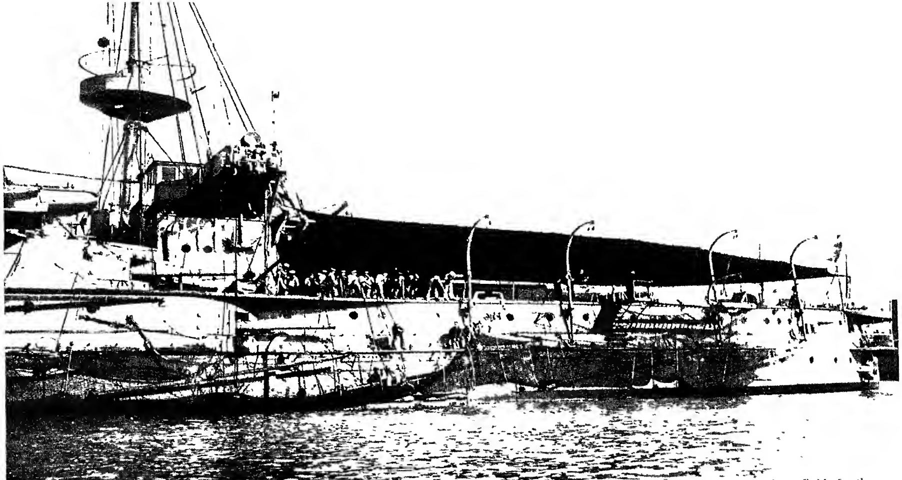
For the past few years the tendency has been to neglect torpedo-boats proper in favour of destroyers, which we have been building in large numbers. It has been found that a destroyer, being slightly larger and very much faster than a torpedo-boat, is much more efficient as a weapon of offence. But to the destroyers has been given an even more important rôle, which they act admirably. Our fleet of destroyers is divided into eight flotillas, called patrol flotillas, whose proud duty it is, in times of peace, to patrol our shores night and day. They act the part, indeed, of sentries of

the high seas. At the present distressful period they have to fulfil these duties with redoubled vigour, in addition to accompanying cruisers and battleships as outposts. At night, in particular, our Dreadnoughts are guarded at sea by a wide circle of destroyers, alert and anxious to catch an enemy's ship in the act of attempting to steal close enough to torpedo one of our giants. Inside this wide ring is a smaller one of light cruisers, inside that larger cruisers, and so on. Four patrol flotillas are attached to the First fleet; the other four, including about eighty boats, are under the control of the Admiral of Patrols, whose office was inaugurated only two years ago.

Each flotilla is accompanied by a light cruiser and a depot-ship. It is considered by many naval authorities that the torpedo depot-ship is the most useful member of our fleet; certainly it is indispensable, and is a most complicated and expensive detail of the naval machine. The patrol flotilla without its depot-ship would be as sheep without a shepherd. The destroyers themselves cannot carry much in the way of reserve stores of any kind, whether of food, ammunition, or spare parts. The depot-ship has to be storehouse, repairing-

shop, and floating-base combined for its little company of boats, and also must be able to put up a good fight for itself if necessary. Naturally, therefore, we may expect to find that the depot-ship carries a wonderfully complete equipment.

Our first ship of this class was the *Hecla*, which as an experiment was highly successful. She taught the Admiralty, however, that the ideal depot-ship would have to be able to defend itself; so her successor, the *Vulcan*, was built on a much more elaborate plan. The *Vulcan* carries enough coal for a cruise of 10,000 miles at a speed of 10 knots, her maximum speed being 20 knots. She is built of steel, with an armoured protective deck guarding her engines, magazines, boilers and other vital parts. In her repairing-shop is every variety of machine and appliance likely to be necessary for repairing and renewing the fabric of her fleet. She carries a carpenter's shop, a joiner's shop, a blacksmith's shop and forge, a blast-furnace, lathes, circular saws, and machines for drilling, planing, slotting, and punching. Huge cranes, worked by hydraulic power, lift in and out the miniature fleet of torpedo-boats which she carries on her upper deck. Of more sinister



C 724 Photo Cribb, Southsea

GUARDING AGAINST THE TORPEDO

Big ships guard against torpedoes by enclosing themselves in steel nets hung out on booms. Opinions vary as to the usefulness of the nets, which are by no means invulnerable

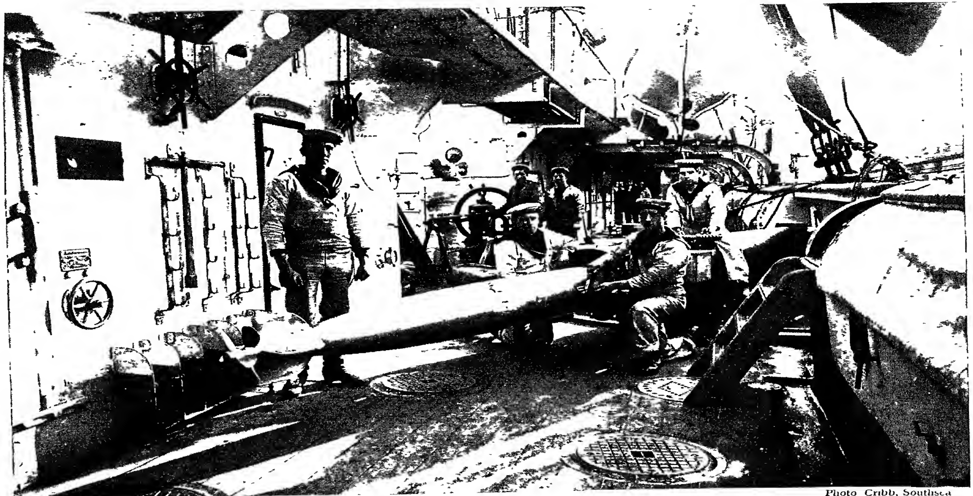


Photo Cribb, Southsea

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CHARGING A TORPEDO WITH COMPRESSED AIR

The torpedo is a mass of exquisite machinery that, driven by compressed air, sends it true to the mark at which it is aimed. The secrets of the newest patterns are kept jealously guarded. Modern torpedoes have a range of travel of from 4 to 5 miles, and cost from £600 to £800.

import is the supply of mines and torpedoes with which she is loaded. She is provided with four Whitehead torpedo-tubes, two of which are submerged and two above water. Her cranes were greeted with derision by seamen of all classes, who declared that they would make the ship roll terribly and would capsize her when loaded. Needless to say, these fears were groundless, the cranes proving quite practical and of no danger whatever to the ship. The *Vulcan* was fitted with torpedo-nets, which modern experience has proved more troublesome than useful, owing to their hampering the movements of the ship and being of no avail against torpedoes fitted with net-cutters. The latest type of mother-ship is a good deal bigger than the *Vulcan*, which has now, I believe, been fitted out as a mother-ship for submarines.

To return to our destroyers, which we have left rather far behind. The training meted out to the men is of necessity very severe. To begin with, it takes a long time to get one's sea-legs on board a destroyer. The rolling, pitching, tossing, heaving, and every form of uncomfortable motion which men sustain on board these little vessels upsets the stoutest equilibrium at first, and the raw hand has to

wrestle with the most poignant form of sea-sickness. In fact, in the early days of torpedo-craft, manœuvres were several times complete fiascos owing to the fact that the crews were prostrated by sea-sickness. The following story, taken from Lieutenant G. E. Armstrong's book, *Torpedoes and Torpedo Vessels*, will illustrate the kind of thing which a sailor on board one of these boats may expect even now in bad weather. It deals with the voyage across the Atlantic of two torpedo-boats which encountered bad weather immediately after leaving Plymouth.

Although the crews were composed entirely of picked men, nearly the whole of them were at the outset violently sea-sick, and it was some time before even the labour of keeping the boats afloat and going succeeded in driving them, as it were, into recovery. The rolling was awful, the boats often being half under water. Everything that was not actually built into the boat was wrenched from its fastenings; and sleep, even when wedged up between boards and blankets, was a practised art. Feeding was also a rough-and-tumble business. Indeed, a few days' existence in a torpedo-boat, even under less trying conditions than those

referred to, creates a curious tendency amongst the crew to revert to the prehistoric condition of man when he lived like a wild beast, ate his food with his fingers, and never indulged in the luxury of a wash unless it was an involuntary one. A quotation from the officer's account will explain how this is: "As a rule", he said, "we lived on ham, sardines, and tinned soups; for most of the time the weather was so rough it was as much as we could do to get a little water boiled. We had a table about 18 inches wide in the cabin, but it was no good having it laid, for nothing would stay on it. The usual plan was for one man to hold the sardine-tin while the other picked out the sardines by their tails and transferred them to his mouth. Ham always required two men, one to hold it and the other to cut it." But these little peculiarities of living were only by the way. What engrossed the attention of the officers and men throughout this dreadful voyage was the task of keeping their vessels afloat.

Fortunately the voyage was accomplished without loss of life, in spite of the fact that these little ships encountered every possible danger in the shape of gale, fog, and ice. They were attended by a depot-ship which had much ado

to keep afloat herself, and could do little to help her charges, though on one occasion she certainly saved them from foundering by pouring oil over her stern. I have mentioned this voyage at some length because it was the first long voyage attempted by torpedo-boats, and proved their sea-going power beyond dispute.

But in spite of, or because of, their discomforts, men on board a torpedo-boat or destroyer are generally very happy. There is freer communication between officers and men —there is bound to be in so confined a space— and though discipline is strict there is not the hide-bound routine which prevails on a larger ship. There cannot be, from the very nature of the work to be done. As Lieutenant Armstrong says: "A torpedo attack which cuts into the greater part of the night, and which keeps everyone on the *qui vive* for hours at a time, is calculated to upset the routine-board of a torpedo-boat, if such a thing existed. Officers and men have to sleep when they can, eat when they get the chance, and be ready for fighting at any moment throughout the twenty-four hours. On the other hand, the watches are kept religiously, and such important duties as cleaning the steel 'babies', or

sounding the well—and, let it be added, serving out the grog—are never neglected. . . . Personal comfort is always sacrificed for the sake of the boat's good name. Indeed, it is hardly an exaggeration to say that the *esprit de corps* to be found on board a properly commissioned torpedo-boat can hardly be surpassed anywhere."

Before being appointed to a ship, recruits to the torpedo service spend a certain length of time in the torpedo school. Here they acquire a great deal of knowledge relating to the following subjects:—

1. Whitehead torpedoes.
2. Mine-laying for the defence of harbours, &c.
3. Electric-lighting.
4. High explosives.
5. Forcible entry of foreign harbours and the means of defence to be combated.
6. Manœuvring torpedo-boats and destroyers by day or night.

The officers on board a torpedo-boat are obliged to have an immense amount of special knowledge on the subjects of electricity and explosives. But no amount of theoretical and practical training on dry land or on a moored

ship can be compared with the value of two or three weeks' active service. Men on torpedo-craft have to be ready for anything. The signalman, for instance, in the intervals of taking and sending messages, does the cooking, washing, and waiting at table—weather permitting. There is no table in rough weather. The lieutenant is expected to know all about electrical appliances, be able to confer with the captain with regard to methods of attack, and, incongruous though it seems, be expert in the gentle art of decorating and lighting halls and ballrooms, in the event of any entertainment being given to a foreign fleet.

You have probably heard or read of the Brennan torpedo. This is quite a different thing from the Whitehead torpedo I have already described. The Brennan is used for the defence of entrances to harbours and narrow waterways generally. The Solent is protected with these torpedoes, and so is the entrance to the Medway, and, I expect, so are many other British passages, though I do not happen to know of them. It is a highly ingenious contrivance, and it works in this way: Inside the torpedo are yards upon yards of very thin steel wire wound upon drums. The ends of the

wire are connected to winding-engines on shore. As soon as these commence to work they unwind the wire on the torpedo's drums, the rapid revolution of which imparts motion to propellers. The faster the engines wind up the wire the faster the torpedo travels forward. The great feature of the Brennan torpedo is that it can be steered. By winding up one wire faster than the other, one of the propellers will revolve faster than its fellow, and so drive the torpedo to port or starboard, as the case may be. It travels so fast, and can be steered so easily, that it is said that no ship can escape it, manœuvre as she may. Of course the torpedo's range is limited to the length of the wire, which is long enough to get across a fairly wide channel.

CHAPTER VIII

The Submarine

ASSUREDLY the greatest and most surprising development of modern warfare is the sudden evolution of the submarine. It is great because it calls into action new methods and new machines, and it is surprising because men have been trying ineffectually to produce a practical boat to travel below the surface for the last four hundred years. Now, after little more than twenty years of scientific investigation and experiment, the submarine has been brought to such a degree of efficiency that we can scarcely predict what it may become in the near future.

There is no need to speak here of its predecessors, the curious productions of the sixteenth, seventeenth, and eighteenth centuries. It is interesting to note, however, that the Americans were the first people to attempt to use the submarine in actual warfare. The submarine vessel was to be useful in many

ways. It could navigate the stormiest seas in perfect calm, it was invisible to the enemy, and it avoided the dangers of pirates and ice; but most important of all, it could carry torpedoes.

In those early days torpedoes were not self-propelling. They had to be taken to the vessel which was to be removed and placed against her. Before the days of the submarine, torpedoes were only a danger after dark, but the American mind was quick to grasp the uses of a boat which could attach torpedoes unperceived at any hour of the day. Robert Fulton, of steam-boat fame, while living in France, successfully demonstrated the possibilities of this form of navigation in 1800. In a boat of his own building he remained under water for four hours, and blew up, by means of a torpedo, an old hulk lying in Brest harbour. Napoleon aided and abetted him in his experiments, but, curiously enough, never included the submarine amongst his weapons of offence. If he had, history might have been written differently. The Americans actually built a submarine for the express purpose of rescuing Napoleon from St. Helena, but it never left American shores. During the American Civil War the Confederates experimented with a submersible boat

designed by Theodore Stoney, and named the *David*; but the story of this trial of the new power is melancholy reading. Three sucessive trips were made, ending each time in the sinking of the boat and the death of the crews. Men were found plucky enough to man her a fourth time, and on this occasion the *David* blew up the Federal ship *Housatonic*. Unfortunately, however, the *David* could not get away quickly enough, and the *Housatonic*, in sinking, carried the *David* down with her.

In the course of this war many ships were sunk by torpedoes, but thereafter interest in the subject of submarine navigation languished until 1875, when an American named Holland began to work seriously to produce a boat which should have all the desirable factors of the *David* and its forerunners and none of their drawbacks. His task was no easy one. A vessel was required which should be able (1) to sail along the surface and to sink to a sufficient depth to be below the hull of a large ship; (2) to keep its balance under water; (3) to be air-tight and water-tight, while carrying enough air to preserve life in several men for a given length of time; (4) to descend or ascend with equal ease and swiftness. The trouble

was, that while many of the boats already built for submarine work had all these good points theoretically, when it came to actual practice they were found to be unreliable. The *David*, for instance, refused to rise. The real reason of modern success in the matter is found, not so much in improvement of design—though that counts for a great deal—as in the improvement and development of material.

In 1885 America decided that she must have submarines. Accordingly she invited the two foremost men then studying the problem—Holland and Nordenfeldt, a Swede—to send in designs. Nordenfeldt responded with a boat that had many good points as a surface boat. The peculiar turtle shape of its back, painted a dull grey—which, with the two little conning-towers, was the only portion of the vessel above water—made a particularly difficult target, while she had the additional advantage of being able to travel noiselessly and without smoke. But she was by no means entirely successful as a submarine. To begin with, she was driven by steam, and when it was desired to go down below the surface the fire had to be put out. Nordenfeldt claimed that the steam was useful as a factor of safety, in

that steam pressure could be used to drive out extraordinary weights of water such as might be caused by a leak. At that time electricity was little understood, and the apparatus in use was clumsy and defective, and therefore it is perhaps not surprising that Nordenfeldt preferred to put his trust in steam. Sufficient steam could be stored in the boilers to drive the vessel a distance of about 20 knots under water after the fires had been raked out. Her greatest fault, however, was that she seemed utterly incapable of maintaining a horizontal position once she descended below the surface. *Nordenfeldt II* and *III* were bought by the Turkish Government, with what result a contemporary number of *The Engineer* graphically describes.

"The Turkish boat was submerged by admitting water to tanks aided by horizontal propellers, and raised by blowing the ballast out again and reversing the propellers. Nothing could be imagined more unstable than this Turkish boat. The moment she left the horizontal position the water in her boiler and the tanks surged forward and backwards and increased the angle of inclination. She was perpetually working up and down like a scale

beam, and no human vigilance could keep her on an even keel for half a minute at a time. Once, and we believe only once, she fired a torpedo, with the result that she as nearly as possible stood up vertically on her tail and proceeded to plunge to the bottom stern first. On another occasion all hands were nearly lost. Mr. Garrett was in the little conning-tower. The boat was being slowly submerged — an operation of the utmost delicacy — before a committee of Ottoman officers, when a boat came alongside without warning. Her wash sent a considerable quantity of water down the conning-tower, the lid of which was not closed, and the submarine boat instantly began to sink like a stone. Fortunately Mr. Garrett got the lid closed just in time, and Mr. Lawrie, the engineer, without waiting for orders, blew some water-ballast out. It was an exceedingly narrow escape. In spite of these difficulties, the Ottoman officers were so impressed that the Turkish Government bought the boat. It goes without saying that it was only with the greatest difficulty the price was extracted from the Sultan's treasury. But no use whatever has been made of her, and she lies rotting away in Constantinople, unless, indeed, she

has found her way piecemeal to the marine-store dealers. A paramount difficulty in the way of utilizing her was that no engineers could be got to serve in her. If men were appointed they promptly deserted."

Clearly a boat so erratic as this was not calculated to advance the cause of the submarine. Nordenfeldt's design was discarded by America in favour of that of Holland, who was commissioned to build a boat after several years had been spent in negotiations. Holland's design, according to the official report, "embodied the ideas of a fixed centre of gravity, of an exact compensation for expended weights, of a low longitudinal metacentric height, and of quick diving and rising by the effort of the propeller pushing the vessel against the resistance of her midship section only down and up inclines, the angles of which were to be determined by horizontal rudder action". The main differences between Nordenfeldt's and Holland's boats were to be found in the steering and the motive power. The *Plunger*, Holland's boat, which was launched in 1897, was built with a steam-engine for use on the surface and an electric motor for use when submerged. Subsequently

the steam-engine was taken out, and in its place an oil motor was substituted. But by this time Holland had made so many important developments of design and construction that he considered the *Plunger* out-of-date, and he offered to return to the Navy Department the sum, some 94,000 dollars, it had spent on the *Plunger* if it would agree to buy a *Holland* of the latest pattern. This offer the Navy Department was glad to accept, and *Holland VIII* and *IX* were built forthwith. *Holland VIII* was unsatisfactory, but *Holland IX* fulfilled the highest expectations of her builder. A gasoline engine provided the power for surface work and an electric motor that for submarine passage.

Through all these years of experiment Great Britain had been standing by, carefully noting the failures and partial successes of France and America, outwardly scoffing, but inwardly taking heed, displaying to perfection her inimitable attitude of indifference. The little men raved and shouted, crying out upon the slackness and inefficiency of those in power, while the big men preserved a non-committal silence. Then, when the spade-work was all finished, and experimental money had all been dispersed

—by other nations—Great Britain gave an order to Vickers-Maxim for five submarines of the Holland type. This was in 1901, and immediately a storm of criticism was aroused. One party declared that if submarines were to be used there was no need to spend any more money on battleships; another deprecated the action of the Government in ordering them without consulting the House of Commons; another had no words too bad for the theory and practice of submarine warfare; while at the best the Government only admitted a cautious desire to learn a little more about the subject. Mr. Arnold Forster, speaking in the House on 18th March, 1901, said: "We have a great amount of information about these boats, but we do not attach an exaggerated value to it. But we believe that an ounce of practice is worth a ton of theory, and that when we get officers and men to see these boats, they will learn more from them than from many reports which come from foreign countries." The same speaker, little more than a year later, was able to announce that the submarines had proved an unqualified success.

Great Britain has been blamed for going abroad for the designs of her first submarines,

but we see now how wise she was to remain neutral on the subject until the moment when she could take action profitably had arrived.

It is curious to read the comments of French naval writers of the time. England was accused of perfidious conduct, of reaping where France had sown. The French seem to have had a fixed belief in the possibility of a war with Britain, and the naval programme of each country was constructed in a spirit of rivalry. Thus, when France built the *D'Entrecasteaux*, a commerce-destroyer of 8000 tons, capable of 19 knots, Britain retorted with the *Powerful* and the *Terrible*, each of 14,000 tons and with a speed of 22 knots. But that rivalry has long since died a natural death, giving rise in its throes to a solid and enduring friendship which is the honour and pride of us all. The first French submarine was named the *Gymnote*, and gave great pleasure to her patrons; but she was not a reliable craft, and several times came near to drowning her crews. She was, however, of great service in initiating the French officers into the practice of submarine navigation, and was used for many years as an instruction-boat. The lessons learnt from the *Gymnote* were apparent in the *Gustave*

Lédé, the first of the French armed submarines, though in the beginning this boat tried hard to suffocate her crews with fumes from the accumulators. She was also very unsteady under water, and plunged up and down in see-saw fashion; on one occasion, when the committee and experts were on board, actually throwing all the passengers to the floor several times. This difficulty, however, was obviated by putting in six rudders, three on each side. As a matter of fact, the *Gustave Lédé* was, to begin with, a creature of moods and impulses, but after several years of experiment and endeavours she was converted into a really serviceable boat. In consequence, public interest was aroused thoroughly at last, and, upon the *Matin* appealing for funds to build one more *Lédé*, sufficient money for two was quickly subscribed.

In spite of the success of French designers, Great Britain has remained faithful to her first choice, the "Holland". *Holland I*, the first submarine she ever possessed, was a curious little vessel. It was only 63 feet long, had only one propeller, and only one periscope, of limited powers. Its compass was disastrously affected by the electric currents with which a

submarine is filled, while its little, low conning-tower afforded only a small view when the vessel was at the surface. Only one torpedo-tube was carried. Holland would never recognize in one of our wonderful modern submarines a direct descendant of one of his own boats.

Outwardly they differ in size and outline. The whole boat is six times as large as *Holland I*, and the conning-tower, furnished with a bridge and two periscopes, is well elevated. The Marconi installation also is a new feature. Internally, of course, there is even less resemblance. A heavy-oil internal-combustion engine drives the twin propellers while the boat is at the surface, and generates the electricity which is the motive power when the boat dives. Enough oil-fuel is carried for a surface journey of 4000 miles, and the electricity stored in the storage-batteries enables the boat to travel below the surface for forty-eight hours. Compressed air, which supports life inside the vessel, is also used to discharge the torpedoes. This was formerly a dangerous operation, the balance of the ship being completely upset; but all that has been altered.

In the boats of to-day there are four torpedo-tubes; as a torpedo is expelled, water

enters into the first of a series of tanks, and, passing from one tank to another, keeps the balance with perfect equality. When under water the boat maintains its equilibrium by ballast and by various devices which are absolutely secret to the outside world. In fact, the construction of a submarine is so entirely a State secret that very little information is forthcoming on the subject. The interior is full of instruments of many kinds. The necessary mechanism takes up a great deal of room. For instance, the steering-gear, the diving-rudders, the gauge for recording the depth, the electric motor for opening the doors of the torpedo-tubes, the two kinds of engine and the multifarious pipes and gauges that they require, the gyroscopic compass which overcomes the difficulty of the effect of electric currents—all these, and other contrivances which will be grasped easily by reference to the diagram on p. 166, form part of the equipment of the modern submarine. Moreover, the boat is doubly armed. It carries torpedoes for use under water and a quick-firing gun for use at the surface. This handy little piece of artillery is mounted on a disappearing platform, so that it can be run up on to the deck,

C 724 Photo Cribb, Southsea

A BRITISH SUBMARINE FITTED WITH WIRELESS TELEGRAPHY

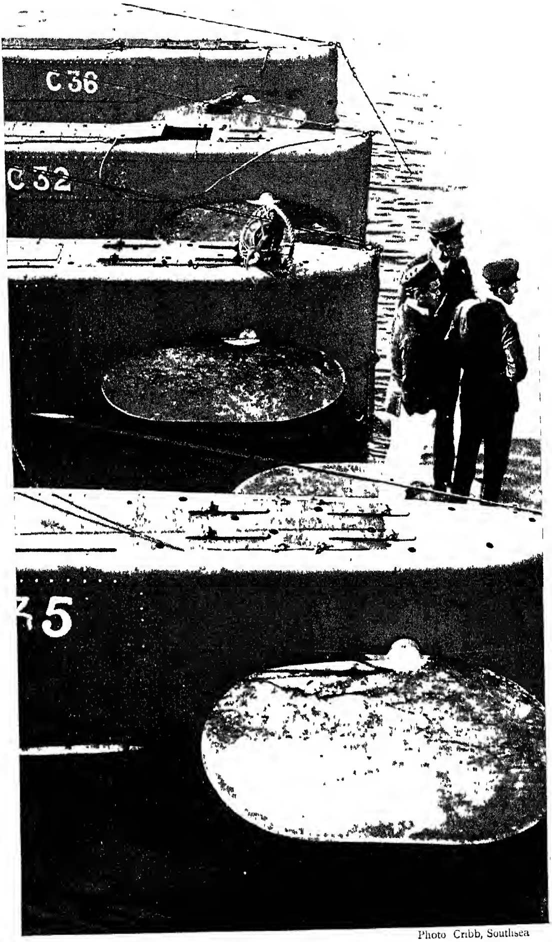


Photo Cribb, Southsea

THE PLANES OF THE SUBMARINE

These horizontal rudders regulate the angle of descent and ascent.

fired, and then dropped back again out of sight. In addition to all these qualifications the submarine is for the time being the home of from fourteen to twenty-eight men, who cook their food by electricity, and, in spite of obvious dangers, declare that they are the happiest men in the Navy.

Our newest submarines, the "E" class, have a surface speed of 16 knots. Their displacement is about 800 tons, and they are armed with four torpedo-tubes and two disappearing quick-firing guns. Their complement numbers twenty-five, including officers. The submarines of the "F" class, now being built with extreme secrecy, are known to be much larger and more powerful than any others of our fleet. They are believed to have a displacement of 1000 tons, and speeds of 19 knots at the surface and 12 below; have six torpedo-tubes and two guns, and carry a crew of twenty-seven officers and men. These meagre details are all that can be obtained relative to these two classes of submarines. The "F" class boats are expected to be able to undertake the duties of submersible destroyers, being capable of long voyages at moderate speed.

The principal submarine depot in this country

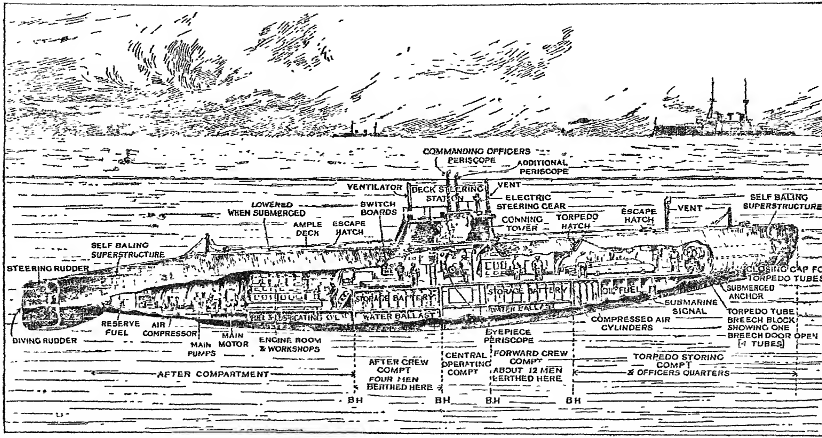


DIAGRAM OF A MODERN "HOLLAND" SUBMARINE

ADDITIONAL DETAILS: Both periscopes are equipped with special range-finding and torpedo-directing apparatus. During surface-cruising, comfortable sleeping accommodation is provided for the two watches off duty in the forward crew compartment. In the central operating compartment is the submerged control, such as diving-gear, air-system control, ballast-tank floods, &c.

is Blockhouse Fort at Portsmouth, and here are moored the submarine depot-ships *Dolphin* and *Arrogant*. At Haslam Creek, where there is a dockyard for submarines, is the training-school for recruits. As may be expected, no one is admitted to the submarine service before proving that he is fitted for it. The medical test is exceptionally severe in the first place, and after a candidate has successfully passed that he is submitted to an even more trying ordeal. This is the nerve test, which is applied to officers and men alike. All hands are assembled on board, the hatches are closed, and the lights turned out. Then the ballast-tanks are filled, and in total darkness the boat sinks down into the depths. The novices have no idea how long the descent is to last, or at what depth below the surface they may be. This performance is repeated day after day, and any man showing the least tendency to "jumpiness" is summarily dismissed as unfit for submarine service.

It can be readily understood that upon the self-control of each member of the crew depends the safety of every other member and of the vessel itself. A body of men boxed up in an hermetically sealed boat at the bottom of

the sea would be utterly at the mercy of any foolish individual who lost his head and did the wrong thing. Moreover, panic is fatally infectious, and the dormant germ must never be admitted into a place so favourable to its development as a submarine. In view of the dangerous nature of their work, officers on board a submarine receive extra wages at the rate of 6*s.* a day, while the men receive an extra 2*s.* 6*d.* a day. Of recent years much has been done to mitigate the peril of submarine work. For instance, every boat now possesses an air-lock—a chamber which will remain full of air even if the rest of the vessel be full of water. In the air-lock are hung a number of appliances, one for each man on board, consisting of a kind of diving-helmet and jacket. In case of disaster, the men go to the air-lock, put on their instruments, open the conning-tower hatch, and are quickly carried up to the surface.

Fortunately, the sad accidents to submarines so common a few years ago are becoming more and more rare. The submarine is now a really practical machine, and under ordinary conditions a voyage in one is no more to be dreaded than a trip in a penny steamer.

It may be remarked here that Sir Percy Scott, whose efforts have increased the efficiency of naval guns so greatly, now asks us to believe that the most superlative of "Dreadnoughts" is obsolete, that the coming of the submarine has rendered all our latest developments of surface warfare out of date. Well, Sir Percy Scott's prophecy may come to pass some day, though that is not likely to happen yet awhile. All the same, battleships take so long to build, and cost such huge sums of money, that it would be a very terrible waste of our resources to go on building them if there was really any danger of their purpose being defeated by the infinitely cheaper submarine. In the present war the submarines have, it is true, given a pretty good account of themselves in the limited sphere of usefulness in which they are designed to play a part. For scouting, for harassing the enemy, they are exceedingly useful. You may remember that in speaking of the successful little flutter in the Heligoland Bight, on 28th August, Mr. Churchill said that the achievement was largely due, in the first instance, to the information brought to the Admiralty by the submarine officers. They had shown, he said, "extraordinary daring

and enterprise in penetrating the enemy's waters".

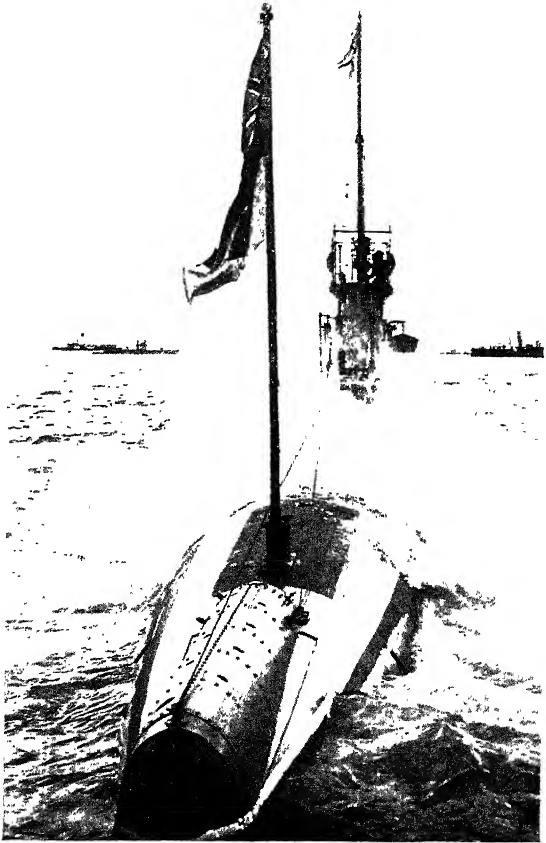
The submarine's great advantage is its invisibility. But all nations are busy building sea-planes that, from their elevated positions—even at so great a height as 3000 feet—are able to detect submarines 18 feet under water, while to a submarine a sea-plane more than 1500 feet above sea-level is quite invisible—at present. The torpedo is the particular weapon of the submarine, and, as was shown in the last chapter, the torpedo has its disadvantages.

It is apparent that the submarine is a thing of surprises, that it has an equipment which prepares it for almost any emergency, and yet one question forces itself to the front. How can the commander, hidden away in the depths of the ocean, find and aim at the object he wants to torpedo? The submarine is enveloped in inky-black waters. It carries no searchlight, for at present there is no apparatus which would have any effect in illuminating the darkness, darker and denser than any night of London fog. One of these days, no doubt, we shall learn a lesson from that extraordinary octopus which uses half its eyes as a phosphorescent light and the other half to see with,

but up to now nothing has been devised for the purpose of lighting the path of the submarine. Up above, however, so long as daylight lasts, there is nothing to obstruct the view, and this view the captain of the submarine borrows for his own use. He is enabled to do this by means of the periscope, one of the most wonderful devices carried by the submarine.

On the top of the one, or two, masts which stand up high above the conning-tower is a series of prisms which reflect, down a telescopic tube, the surrounding ocean and all that it contains. Where there are two masts fitted with periscopes, one reflects the distant and the other the near view. Thus, when the navigation officer of the submarine wants to look about him, the vessel is raised so that the periscope, and only the periscope, stands up above the water. Meanwhile the officer stands looking through a pair of binoculars attached to the base of the periscope tube. By turning a wheel he is able to look at any quarter of the horizon he chooses. But, wonderful though it is, the periscope is not enough to ensure the safety of the submarine. When the periscope is under water it can reflect nothing, and therefore there is no means of preventing the vessel

from rising directly underneath a man-of-war, or running headlong towards another submarine. It is to be hoped that before very long one of our great inventors will find the solution of this difficulty. It has been suggested that an electrical machine could be contrived which would be sensitive enough to "feel" and record the proximity of any large metal body. Once such a result had been achieved, the exact location of such a menace would not be a very serious matter. Its "blindness" is really the greatest danger to the submarine. Other weak spots have been detected and remedied, at the cost of many brave lives, but this peril of collision remains obstinately grave.



C 724 Photo Cribb, Southsea

THE TERROR OF THE SEAS

E8, one of the latest British submarines, running on the surface

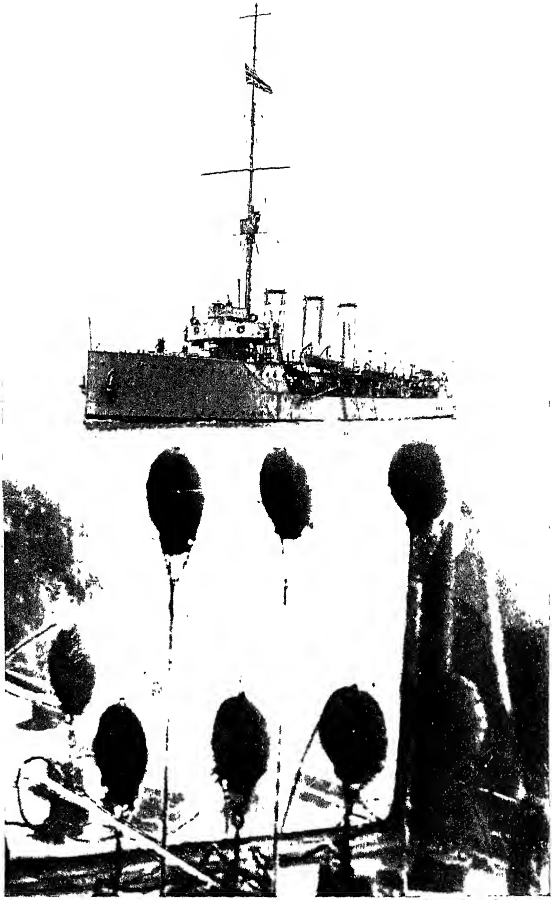


Photo. Cribb, Southsea

THE MINE PERIL

The indiscriminate sowing of Mines by the Germans in the North Sea was responsible for the loss of several vessels, including H M S. *Amphion*. Frequently, dropped mines become unanchored and thus drift out of their original position.

CHAPTER IX

Mines and Mine-laying

THE subject of submarine mines has received more attention during the present war than in any previous campaign, for obvious reasons. The Spanish-American War was a short and sharp encounter, and good use of mines was made by both sides in the Russo-Japanese War, but with those two exceptions there have been no naval encounters since the Russian War of 1854, when the art of mine-construction was still in its infancy. Nowadays mines are cruelly efficient, and have been responsible already for a long Roll of Honour. But the matter which has aroused so much discussion is the infamous and illegal practice of the Germans in mining the open sea. Hitherto no nation engaged in war has violated the rule which requires that mines should be laid only within territorial waters. The Germans have seen fit to ignore that rule, just as throughout this campaign they have ignored the rules, not only of civilized

warfare, but of common humanity. Unfortunately a large number of non-combatants, inoffensive fishermen pursuing their daily trade, have been amongst those killed, so that our own Admiralty have had to adopt retaliatory measures, and have counter-mined certain areas of the North Sea.

Mines resemble torpedoes and submarines in that their moral effect is as great, in one sense, as their actual results. Many and many a commander would hesitate to take his ship into a harbour which he knew to be thickly sown with mines, while he would welcome a chance of coming to grips with one of the enemy's ships in open and above-board manner. The bravest may be excused for faltering before dangers which they cannot see. For this reason mines are extensively used as defences for harbours and coast-lines, and it is these hidden dangers, far more than visible forts and batteries, that would deter a hostile fleet from trying to enter the Thames or the Humber or the Firth of Forth. To touch a mine is certain destruction, until some instrument can be found, as suggested by Sir Arthur Conan Doyle in the *Times*, which can be fixed in front of ships to explode mines harmlessly before them.

The mine owes its efficiency to our old friend gun-cotton. One of the many interesting and useful points about mines is that they can be improvised out of very unpromising material, and in such a case a strong charge of gunpowder, or any other explosive that could be obtained, might be used. But a real mine, that is to say, one that is made in the naval arsenal in the most scientific and up-to-date way and of the best materials procurable, is terribly certain in its effect. Submarine mines are of two kinds, observation-mines and contact-mines. Observation-mines are those which are fired by an operator on shore, and contact-mines, as the name implies, explode automatically when touched by the keel of a vessel.

The observation-mines are chiefly used for purposes of defence. The laying of them is an operation requiring great care and precision. The preparation of the mine itself is naturally the first step. The outer case is a cylindrical shell of iron about $32\frac{1}{5}$ inches in diameter and 34 inches long. It is provided with eye-bolts at the top for the sling to pass through, and at the bottom for the attachment of the sinker chains. Inside the case the charge—about 500 pounds of damp gun-cotton—is packed in

a number of copper cases arranged in tiers, each case having holes for re-wetting the charge. In the centre of the charge is the primer tin, which, as in a torpedo, is filled with dry gun-cotton packed round two detonators. The wires which lead into the mine are passed through an insulating plug fitted in the mouthpiece. It is most important that this insulating plug should be kept water-tight, and for this end the wires are fitted with "puddings", gland-nuts and leather washers. The testing of the insulating-plug is always an important feature of mine-laying preliminaries. Sinkers, weighing about 5 hundredweight, made of wrought iron and rather like an orange in shape, with a concave bottom to give suction-power, are attached to the bottoms of the mines by means of flexible steel-wire rope. Mines of this kind may be laid from an ordinary launch, although there is, of course, a type of launch specially designed for the purpose.

Suppose it is required to lay six mines from a 42-foot service-launch. First four strong thwarts are fixed across it and a little fence, or, in nautical parlance, a wash-strake, of canvas is fitted round the gunwale to keep the boat dry. Then, the slings and sinkers being all in

position, the mines are lowered into the boat with the greatest caution.

Two mines are placed on each thwart, the fourth thwart being occupied by the *Inner Mark buoy*, the use of which will become apparent presently. The cable is, let us say, 1440 feet long, and six branch cables fork from it at intervals of 180 feet, leaving 90 feet clear at one end and 450 feet of "stray" cable at the other. The lengths of cable in between the forks have to be most carefully coiled in the bottom of the boat, and each branch cable is secured to its respective mine. The 90-foot end of the cable is insulated and is attached to a little barrel—a barricoe. A grass-line, that is to say a rope which floats on the surface, marked at intervals with bunting, forms part of the equipment of the mine-laying launch, and, when hauled taut, shows the operators the exact points at which to drop the mines. The first thing to be placed in position is a mark buoy, to which the grass-line is fastened. Here the barricoe is thrown overboard and serves to mark the outer end of the chain of mines. Now the launch proceeds slowly on its way, the grass-line running out over the side. As each piece of bunting goes overboard a

mine is sunk. When the last mine has gone, the inner mark buoy and sinker are dropped, the grass-line is removed, and the end of the cable is taken to the junction-boat or station.

But it would never do to leave two mark buoys witness to the presence of a string of death-dealing mines, so other buoys of the same size and kind are sprinkled about in the neighbourhood. Only the operator on shore knows with certainty which are the real and which the dummy marks. When in position, mines should never be less than 12 feet above the cable, as if they are too near there is a danger that the force of the explosion nearest the battery might cut the cable before the next mines had fired. They are generally sunk to a depth of 50 feet below the surface. Six mines such as have just been described would be sufficient to defend a channel over 700 feet wide. When the observer, whose cabin is discreetly hidden amongst the natural features of the country, sees an enemy ship pass one of the mark buoys of his field he presses the button of his battery, and electricity does the rest.

Contact-mines are much simpler to lay than observation-mines, but they are less desirable, since they may be struck with equally fatal

results by a friendly ship as by a hostile one. The charge contained in an electro-contact-mine is very much smaller than that in an observation-mine. In construction the contact-mine greatly resembles the observation-mine, the difference being found, of course, in the method of firing. In the contact-mine a pedestal stands above the charge, on which is placed an instrument called the circuit-closer. This consists of a steel cylinder through the mouth of which passes an iron spindle carefully insulated from the body of the cylinder. The striking of the mine causes the circuit-closer to tilt over, and when it inclines at an angle of 70 degrees the end of the iron spindle comes into contact with the mercury which occupies the lower half of the cylinder. The circuit is thus completed, and an electric spark ignites the primer. The mines are often laid in groups of three.

Electro-mechanical mines are much the same as electro-contact mines in construction, but instead of having a circuit-closer they have a circuit-breaker. A cylinder containing mercury completes the circuit as before when the mine is tilted, but the circuit-breaker comes into use as soon as the mine enters the water.

It consists of a brass cylinder in which are two insulated wires ending in copper disks. Between the disks is poured some melted sugar, which hardens in cooling and forms a solid cake; but when the mine is lowered into the water the sugar dissolves, and finally allows the two disks to come together. When a ship strikes the mine it tilts it, and a vessel of mercury is upset and connects the terminals of both wires. There are many other forms of contact-mine, and it is quite impossible to describe all of them here.

The last-mentioned mines are dangerous alike to friend and foe. Should they break loose from their moorings—as they do sometimes in rough weather—they might work incalculable damage amongst the fleet which had laid them. They are, however, the easiest of all mines to put down, since there are no troublesome cables and connections to consider. For this work a ship, generally a light cruiser, having part of its stern cut away, is used. Under the raised poop thus obtained rails are laid down on the deck of the ship extending out over the water astern. Then, when the mines are ready to be laid, the ship pursues a leisurely course, while the mines are rolled down the

WHEN THE MINES EXPLODE

Balked of its natural prey—a ship of war—the detonated wet gun-cotton hurls great sheets of water into the air.

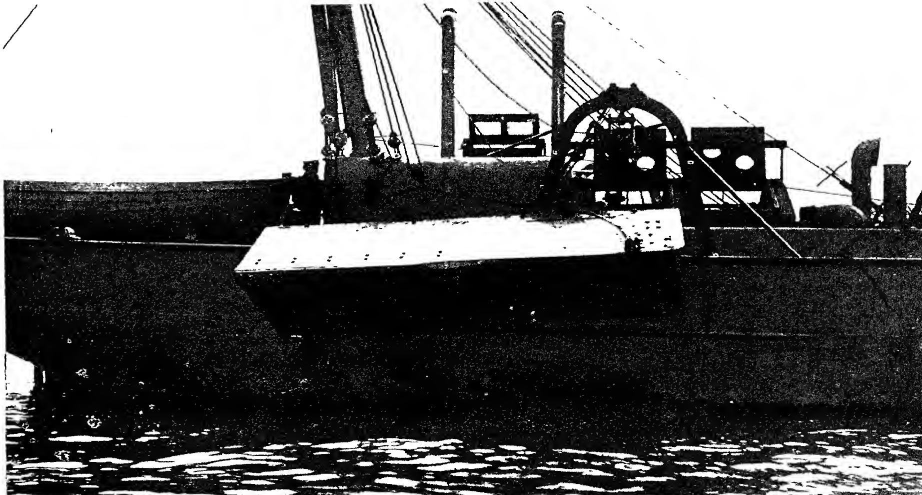


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Photo. Cribb, Southsea

THE "KITE" WHICH IS DRAWN BY A MINE SWEEPER

The kite is used to keep the cable with which the mines are tripped at the correct depth.

rails straight into the sea. Mine-laying ships are provided with elaborate workshops where the mines can be tested and, if necessary, repaired before laying. They also have large magazines of compressed gun-cotton, and can deal out enough destructive matter to sink a fleet.

Fortunately for us, however, it is equally easy, and little more dangerous, though a considerably longer business, to sweep the sea clear of hostile mines. For this purpose boats of the North Sea trawler type are used. At the present crisis large numbers of trawlers have left their legitimate occupation to take up the more pressing matter of sea-sweeping. Captains and crews of these vessels are particularly fitted for the work, since in the ordinary way they spend their time trawling with heavy nets, and the action of sea-sweeping is rather similar. Two trawlers, steaming slowly a wide distance apart, carry between them a "sweeping-wire", which they allow to trail along the sea-floor. A heavy sinker or "kite" keeps it in position. The wire catches the mooring chains of mines and drags them together, the ships being so far away that they will not be damaged even if one or two mines explode. When a number of

mines have been brought together in this way they are fired at and exploded wholesale. The trawler crews employed in this work receive double wages, and doubtless they are glad to run a little extra risk to earn them; though, as a matter of fact, accidents rarely occur to vessels employed in sea-sweeping. We have five boats attached to the Navy for this especial purpose. They are the *Sea-flower*, *Seamew*, *Sparrow*, *Spider*, and *Driver*, and were all originally trawlers.

CHAPTER X

The Menace of Air-craft

THIS war presents one feature which has been lacking in all previous campaigns. Weapons of one kind or another, money, and men have always been necessary to successful fighting. That a man on the march is no stronger than his feet, and a man in the firing-line is no stronger than his stomach, are axioms too old and obvious to need repetition, but we have never before heard nearly so much about *nerves*. Nerves are, I admit, a recent development of the constitution of the male human animal, but never before, in all the histories of all the wars, has there been anything like the strain on the nervous system now being endured by our men. The sailors are passing much of their time in galling inaction, exactly the conditions most suitable for cultivating "jumpiness". They are waiting to fight a foe who, though he will not come out into the open, may at any minute send a fleet of submarines to deal out destruc-

tion. The terror of mines, too, must be ever present.

Equally wearing is the torture inflicted on our soldiers, although, fortunately, they have had too much hard work to be able to spend much time in worrying. When they lie in the trenches they may see between them and the sky a speck—a speck generally stationary, but given to slow circling movements. It is not a vulture, but something more sinister still. It is an aeroplane, carrying a man equipped with every device to help him in his task. Trenches, embankments, ambuscades are of little use now. The airman is peering down through his glasses, noting the positions of men and guns. Presently he will signal to his friends telling them exactly what range and elevation will be required for effective shooting. Meanwhile the soldiers appreciate for the first time the feeling of a small bird or mouse, fascinated by the cruel hawk which flutters over it for such an eternity of seconds. The aeroplane itself rarely seems to shoot or to drop bombs, thereby dispelling one of the long-cherished illusions of the great British public. It is a difficult matter to drop bombs with any degree of accuracy from a height of some

thousands of feet, and if the aeroplane were to descend low enough for the airman to be sure of his mark, he would himself afford a mark for the gunners below. So long as the machine remains a mere speck it is safe, but we may be sure that once within range its life would be speedily brought to an end.

The development of air-craft of all kinds has necessitated a parallel development of guns specially adapted for destroying them. A particular kind of shell has been invented which leaves behind it a trail of thick, black smoke, giving the gunner a guide by which to correct his aim. At close range an aeroplane is little more difficult to hit than any other moving target, but it rarely comes within close range. The work for which it is suited pre-eminently—the work of scouting—can be done nearly as well from a moderate elevation as from a low one, provided no thick clouds intervene. At night the airman can light up a battlefield, and disclose the troops, by dropping a brilliant searchlight attached to a parachute. This light burns brightly for several minutes, and gives him ample time to find out all he wants to know, while he is in no great danger, since the men below are blinded momentarily by the

searchlight, and before they can recover the airman has sailed out of range.

For some years past the great firms of gun-makers have been agitated by the problem of anti-aircraft guns. Experiments in this new branch of the industry are expensive to carry out, since at present we have no obsolete aeroplanes or air-ships to use up as targets, and a captive balloon is but a poor substitute. Moreover, shelling an aeroplane or an air-ship is like shelling nothing else. It has been found that the thin skin of the air-ship offers too little resistance to fire the ordinary shell-fuse, while the speed at which it flies renders shrapnel ineffective, and its great elevation defies even howitzers. This shows us the three main points required in an anti-aircraft gun—high elevation, flatness of trajectory, and speed of projectile, which must also be fitted with a highly sensitive fuse. The shell which leaves a trail of black smoke I have already mentioned. The fullest use of this, however, can be made only with a gun of which the line of fire can be changed with great rapidity. Messrs. Krupp produced in 1910 a gun of 75 mm. calibre which fulfils all these requirements. Messrs. Vickers also have a gun which fires a projectile weighing

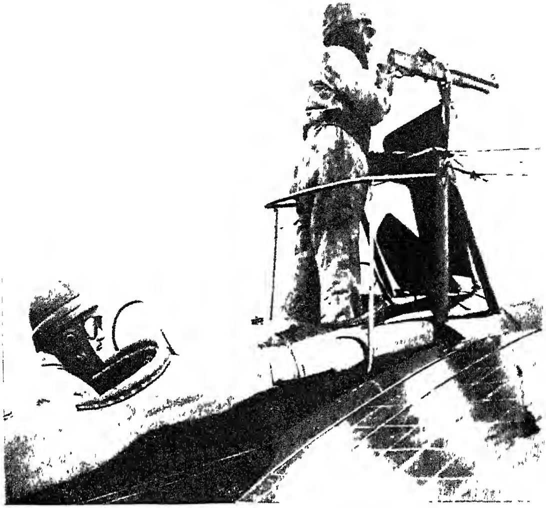
10.841 pounds at a very high speed, and can be elevated to any angle. They claim that twenty-five rounds a minute can be fired from this gun. Ships of the "Iron Duke" class carry two 8-inch anti-aircraft guns, but it must be understood that such weapons are still in their infancy. In actual practice it has been found that, owing to their many air-tight compartments, it is extremely difficult to destroy the gas-bags of air-ships. An aeroplane also presents great difficulties to the gunners. The best results from below have, up to the present, been achieved by firing a stream of rifle bullets, aimed at some point well in advance. Before the outbreak of the war the Coventry Ordnance Company had been making extensive trials with a 1-pounder automatic machine-gun for use in aeroplanes and air-ships, and no doubt by this time it has proved its worth in actual warfare.

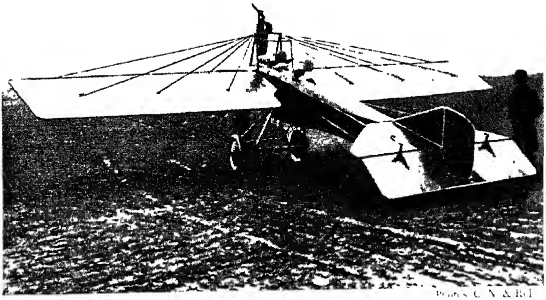
In *The Times* of 14th September was published a letter from a private, in the course of which he tells the following story:—

"There was one interesting sight I saw as the column was on the march, and that was a duel in the air between French and German aeroplanes. It was wonderful to see the Frenchman manœuvre to get the upper position of

the German, and after about ten minutes or a quarter of an hour the Frenchman got on top and blazed away with a revolver on the German. He injured him so much as to cause him to descend, and when found he was dead. The British troops buried the airman and burnt the aeroplane. During that day we were not troubled by any more German aeroplanes."

This little story reminds us that, after all, the guns and the machines are of secondary importance, and that the man concerned is the crux of successful aviation in warfare. We Britons have reason to be thankful that our men are what they are. In our usual spirit, called prudence by its friends and procrastination by its enemies, we dallied with the question of flight, and dawdled and delayed, while our neighbours were achieving and building. Germany had formed an opinion upon air-craft, and France had established a scheme of aerial defence, before our authorities ever gave a sign of having heard of the new means of locomotion. We must not be too hard upon them, however, for to the credit of the powers that be it must be admitted that their methods, in the circumstances, have been the cheapest in the end. Neither in the matter of submarine navigation





Photos C N & R I

TWO VIEWS OF AN ARMED AND ARMOURED AEROPLANE

Many sensational duels in the air have already been fought in the Great European War In the top picture the man exposing only his head and shoulders above the armour is the pilot, while the "observer", who is the marksman, is manipulating a quick firer

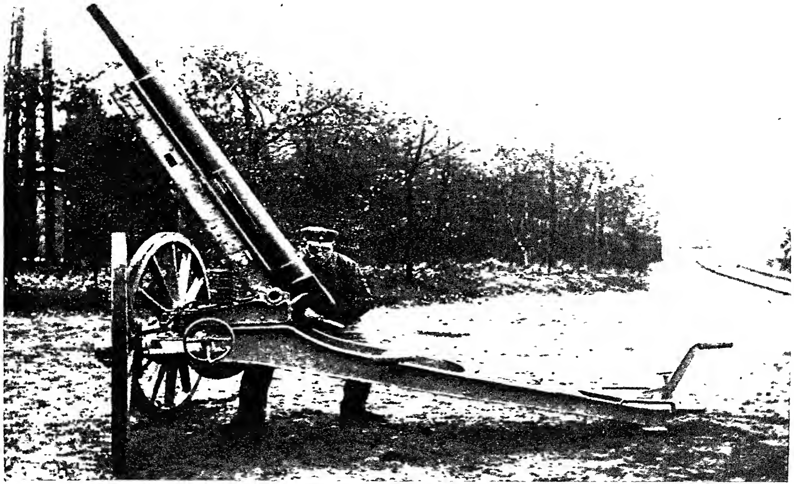


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Photo. Record Press

HOW THE GERMANS FIGHT AIR-CRAFT: A KRUPP 6.5-CENTIMETRE GUN

nor flight did they waste thousands on experiments as other countries have done. Naturally, if we had been involved in war five years sooner we should have had cause to complain, but we may at least admit that our leaders knew perfectly well what they were about.

The formation of the Royal Flying Corps has been largely the work of one man, Brigadier-General Sir David Henderson, K.C.B., who, while holding the post of Director of Military Training, learned to fly in his spare time, and made himself a master of the theory as well as the practice of flying. The result of his labours expressed itself in the formation of a flying corps, and ultimately he obtained his reward by being offered the position of Director-General of Military Aeronautics. With the help of Captain Godfrey Paine, R.N., M.V.O., C.B., Commandant of the Central Flying School, and Lieutenant-Colonel Sykes, Sir David Henderson has built up a new branch of service, which, for efficiency and enterprise, may well be said to have no superior in the world, taking into consideration the very short time it has been in existence. Sir David Henderson went abroad with Sir John French, and the way in which his men have acquitted themselves

must be a source of continual gratification to him. For this is the first war in which air-craft has taken any part, and Great Britain—the laggard, the indifferent, the country which has ceased to count—already has obtained something approaching mastery of the air. The message of General Joffre to Field-Marshal Sir John French leaves no doubt as to the value of the work done. "Please express", he says, "most particularly to Marshal French my thanks for services rendered on every day by the English Flying Corps. The precision, exactitude, and regularity of the news brought in by its members are evidence of their perfect organization and also of the perfect training of pilots and observers."

Observation is at present the job allotted to our airmen. To carry it out needs tireless energy, and it has been stated that, for twenty days up to 10th September, the daily flights of our men reached an average of 900 miles. On many occasions, too, British airmen have shot German airmen and forced them to descend, while on other occasions it has been proved that bombs have been dropped with deadly effect. Said *The Times* of 15th September: "The British Flying Corps has suc-

ceeded in establishing an individual ascendancy which is as serviceable to us as it is damaging to the enemy. How far it is due to this cause it is not possible at present to ascertain definitely, but the fact remains that the enemy have recently become much less enterprising in their flights. *Something in the direction of the mastery of the air has already been gained.*"

That Great Britain depends mainly upon her fleet for her existence is to-day a trite remark; but I want to follow it with another, not quite so trite, but just as obvious when one considers the position. This is, that Great Britain's mighty fleet will have to depend for its existence, in the near future, on the excellence and efficiency of its air-craft. Just as the arrival of the submarine has been claimed to have found the pregnable point of a Dreadnought, so the development of the sea-plane may be said to have nullified the mission of the submarine. As a matter of fact, neither of them has done any such thing. We cannot yet see the end of these two new developments of modern genius, but certainly we cannot predict that either of them will be so supremely successful as to render ineffective any other sort of service. The sea-plane is a scout for the assistance of warships,

just as the aeroplane is a scout for the assistance of armies. The sea-plane can be launched from a warship under way, can fly ahead of it, and, by means of "wireless", give notice of hostile ships at least 60 miles away from its floating base. The pilot of a sea-plane knows no horizon—it is too far away for him to see—but it is possible for him to see vessels 20 miles ahead when he himself is 40 miles ahead of his ship, to signal all necessary information, and return, all within the space of a pleasant morning's ride. He can see the submarine skulking below the surface or pick out the very slight wake left by the shaft of the periscope, which is often invisible from the warship. Or, heavily loaded with bombs, the seaplane can set out from its ship, fly over land and drop its destructive agents, and return again without incurring danger of any kind. Clearly the sea-plane is likely to have performed some famous deeds when the war is done.

IN GREAT BRITAIN
Villafield Press, Glasgow, Scotland